NASA Technical Memorandum 4369

OAST Space Technology Accomplishments FY 1991

NASA Office for Aeronautics and Space Technology
Washington, D.C.

National Aeronautics and
Space Administration

Office of Management

Scientific and Technical
Information Program

1992

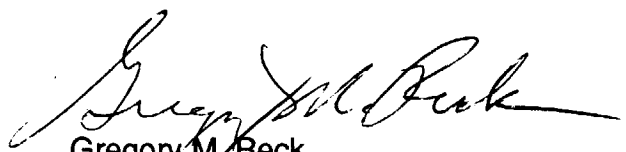
FOREWARD

The Space Research and Technology (R&T) program conducted by NASA's Office of Aeronautics and Space Technology (OAST) provides technology for future civil space missions to enhance mission safety and reliability, increase productivity and performance, reduce costs of space missions, and provide the technological basis for evermore challenging and beneficial missions in the future.

The program consists of a continuum of space research and technology activities ranging from initial research to the full-scale test of prototype equipment in space. Activities include work that is performed by in-house staff at the NASA Centers, University researchers supported by NASA-funded grants and contracts, and industrial aerospace organizations under contract to NASA. These diverse activities provide advances in technology in all important space disciplines, to meet current and future mission needs, and technology breakthroughs that may revolutionize a technical discipline or mission concept. The work is managed and coordinated by OAST through a process that integrates the best available talent and capability in NASA, industry, and universities into a National civil space research and technology program.

The space R&T program structure includes two major components: the R&T Base, which addresses result-driven research or technology opportunity-driven R&T activities; and the Civil Space Technology Initiative (CSTI), which incorporates a series of focused programs directed at meeting the technology needs identified by civil space mission planners (see diagram below).

This book contains accomplishment highlights of OAST's FY1991 program which was executed at the Langley, Lewis, and Ames Research Centers, the Goddard and Marshall Space Flight Centers, the Johnson Space Center, and the Jet Propulsion Laboratory. Point of contact names listed on the contents page correspond to the individuals (Center or Headquarters) who constructed the charts.



Gregory M. Reck
Director for Space Technology
Office of Aeronautics and Space Technology

INTEGRATED TECHNOLOGY PLAN FOR THE CIVIL SPACE PROGRAM

SPACE RESEARCH & TECHNOLOGY

RESEARCH & TECHNOLOGY BASE

DISCIPLINE RESEARCH

- Aerothermodynamics
- Space Energy Conversion
- Propulsion
- Materials & Structures
- Information and Controls
- Human Support
- Space Communications

UNIVERSITY PROGRAMS

SPACE FLIGHT R&T

IN SPACE TECHNOLOGY EXPTS

SYSTEMS ANALYSIS

CIVIL SPACE TECHNOLOGY INITIATIVE

SPACE SCIENCE TECHNOLOGY

- Science Sensing
- Observatory Systems
- Science Information
- In Situ Science
- Technology Flight Expts.

PLANETARY SURFACE TECHNOLOGY

- Surface Systems
- Human Support
- Technology Flight Expts.

TRANSPORTATION TECHNOLOGY

- ETO Transportation
- Space Transportation
- Technology Flight Expts.

SPACE PLATFORMS TECHNOLOGY

- Earth-Orbiting Platforms
- Space Stations
- Deep-Space Platforms
- Technology Flight Expts.

OPERATIONS TECHNOLOGY

- Automation & Robotics
- Infrastructure Operations
- Info. & Communications
- Technology Flight Expts.

FY1991 Space Technology Accomplishments

Thrust	Area	Element	Div	Accomplishment	POC	Ctr	Phone
SCIENCE	Sensing	Direct Detectors	RC	HgZnTe 1x270 Array	Bill Miller	LaRC	(804) 864-1720
			RC	Silicon-Compatible Infrared Sensors	Marty Sokoloski	HQ	(202) 453-2748
			RC	Silicon Micromachined IR Tunnel Sensor	Marty Sokoloski	HQ	(202) 453-2748
			RC	Germanium BIB Detector Arrays	Marty Sokoloski	HQ	(202) 453-2748
		Submillimeter	RC	SIS Mixer Elements	Peg Frierking	JPL	(818) 354-4902
		Laser Sensing	RC	2 micron laser for LIDAR	Norm Barnes	LaRC	(804) 864-1630
	Observatory Systems	CSI	RM	Micro Dynamic Component Tester	Bob Hayduk	HQ	(202) 453-2962
		Coolers&Cryogenics	RC	Low-Vibration Stirling Cycle Cooler	Ron Ross	JPL	(818) 354-9349
	In-Situ Science	SAAP	RM	AOTF-based imaging spectrometer for SAAP	Kim Aaron	JPL	(818) 354-2816
OPERATIONS	Automation&Robotics	Telerobotics	RC	Automated Assembly of Space Structures	Dave Lavery	HQ	(202) 453-2720
			RC	Advanced Teleoperation	Dave Lavery	HQ	(202) 453-2720
		Artificial Intelligence	RC	Astronaut Science Advisor	Michael Compton	ARC	(415) 604-6776
			RC	Autoclass IV	Peter Cheeseman	ARC	(415) 604-4946
			RC	Real-Time Data System (RTDS)	Tom Kaluelage	JSC	(713) 483-0790
			RC	SHARP	David Atkinson	JPL	(818) 306-6170
			RC	Scientific Analysis Assistant	David Atkinson	JPL	(818) 306-6170
	Information and	Space Data Systems	RC	Lossless Data Compressor	Dan Dalton	GSFC	(301) 286-5659
	Communications		RC	Imaging Spectrometer Flight Processor	Jeff Bauers	JPL	(818) 354-4118
			RC	High Speed Optic Transceiver	Herb Hendricks	LaRC	(804) 864-1536
			RC	Digital Autocorrelator Spectrometer	Kumar Chandra	JPL	(818) 354-8519
			RC	Spaceflight Optical Disk Recorder	Tom Shull	LaRC	(804) 864-1874
			RC	Intelligent Data Management	Robert Cromp	GSFC	(301) 286-4351
			RC	Advanced Digital SAR Processor			
			RC	Astro Star Tracker			
PLANETARY	Surface Systems	Planetary Rovers	RC	Autonomous Mobile Exploration Robot	Dave Lavery	HQ	(202) 453-2720
SURFACE			RC	Mini-Rover Technology	Dave Lavery	HQ	(202) 453-2720
		High Capacity Power	RP	Stirling Cold End Motoring Test	Jim Dudenhuefer	LeRC	(216) 433-6140
		Nuclear Power	RP	SP-100 Thermoelectric Multicell	Jack Mondt	JPL	(818) 354-1900
	Human Support	Regen Life Support	RP	Regenerative Life Support	Peggy Evanich	HQ	(202) 453-2868

FY1991 Space Technology Accomplishments

Thrust	Area	Element	Div	Accomplishment	POC	Ctr	Phone
TRANSPOR-	Earth-to-Orbit	ETO Propulsion	RP	New CFD Tools for Turbine Blade Design	Bill Escher	HQ	(202) 453-2858
TATION	Transportation		RP	Main Combustion Chamber (MCC)	Bill Escher	HQ	(202) 453-2858
			RP	High Aspect Ratio Cooling Channel Designs	Bill Escher	HQ	(202) 453-2858
			RP	Thrust Chamber Critical Test (TRW)	Bill Escher	HQ	(202) 453-2858
			RP	Ceramic Composite Engine Parts	Bill Escher	HQ	(202) 453-2858
			RP	Ceramic Balls for Long-Life Ball Bearings	Bill Escher	HQ	(202) 453-2858
	Space Transportation	NEP	RP	Nuclear Electric Propulsion	Tom Miller	LeRC	(216) 977-7101
		NTP	RP	Nuclear Thermal Propulsion	Tom Miller	LeRC	(216) 977-7101
		Cryo Engines	RP	Advanced Expander Testbed (AETB)	Bill Tabata	LeRC	(216) 977-7534
		Cryo Fluid	RP	Multi-Layer Insulation Technology	Frank Curran	HQ	(202) 453-2854
PLATFORMS	Earth Orbiting	Structures&Dynamics	RM	CSI Benefits studies (increased damping)	Bob Hayduk	HQ	(202) 453-2962
	Platforms		RM	SSF Hybrid Scale model	Bob Hayduk	HQ	(202) 453-2962
			RM	Simulated EVA Assembly	Harold Bush	LaRC	(804) 864-3124
R&T BASE							
	Aerothermodynamics	Advanced Technology	RS	PLS Benchmark Study	Dave Stone	HQ	(202) 453-8683
			RF	Optimized PLS HL-20 Database	Dave Stone	HQ	(202) 453-8683
			RC	PLS Approach & Landing Simulation Study	Dave Stone	HQ	(202) 453-8683
			RF	Ceramic Matrix Composites	Bill Feiereisen	HQ	(202) 453-2820
			RF	Flow Density Msmts using Holographic I/F	Bill Feiereisen	HQ	(202) 453-2820
			RF	Magellan Aerobrake Gas Flow Predictions	Bill Feiereisen	HQ	(202) 453-2820
	Space Energy	Advanced Technology	RP	Adv Concr Photovoltaic System	Mike Pisczor	LeRC	(216) 433-2237
	Conversion		RP	High Cycle Life Rechargeable Lithium Battery	Gerry Halpert	JPL	(818) 354-5474
			RP	NASCAP/LEO SSF Design Improvements	Dale Ferguson	LeRC	(216) 433-2298
			RP	Advanced Photovoltaic Solar Array (APSA)	Paul Stella	JPL	(818) 354-6308
	Propulsion	Advanced Technology	RP	Hot Rocket Technology	Frank Curran	HQ	(202) 453-2854
			RP	High Power Electric Propulsion (MPD)	Frank Curran	HQ	(202) 453-2854
			RP	Foil Bearing Technology	Frank Curran	HQ	(202) 453-2854
			RP	Brush Seal Technology	Frank Curran	HQ	(202) 453-2854
			RP	Molecular Computational Fluid Dynamics	Frank Curran	HQ	(202) 453-2854
	Materials&Structures	Advanced Technology	RM	TUFI Thermal Protection Material	Bob Hayduk	HQ	(202) 453-2962
			RM	Adaptive Unstructured Meshes	Bob Hayduk	HQ	(202) 453-2962
			RM	Tin-Containing Polymide	Bob Hayduk	HQ	(202) 453-2962
			RM	LDEF Summary	Bob Hayduk	HQ	(202) 453-2962
			RM	LDEF Ionizing Radiation	Bob Hayduk	HQ	(202) 453-2962
			RM	LDEF Meteoroid and Debris	Bob Hayduk	HQ	(202) 453-2962

FY1991 Space Technology Accomplishments

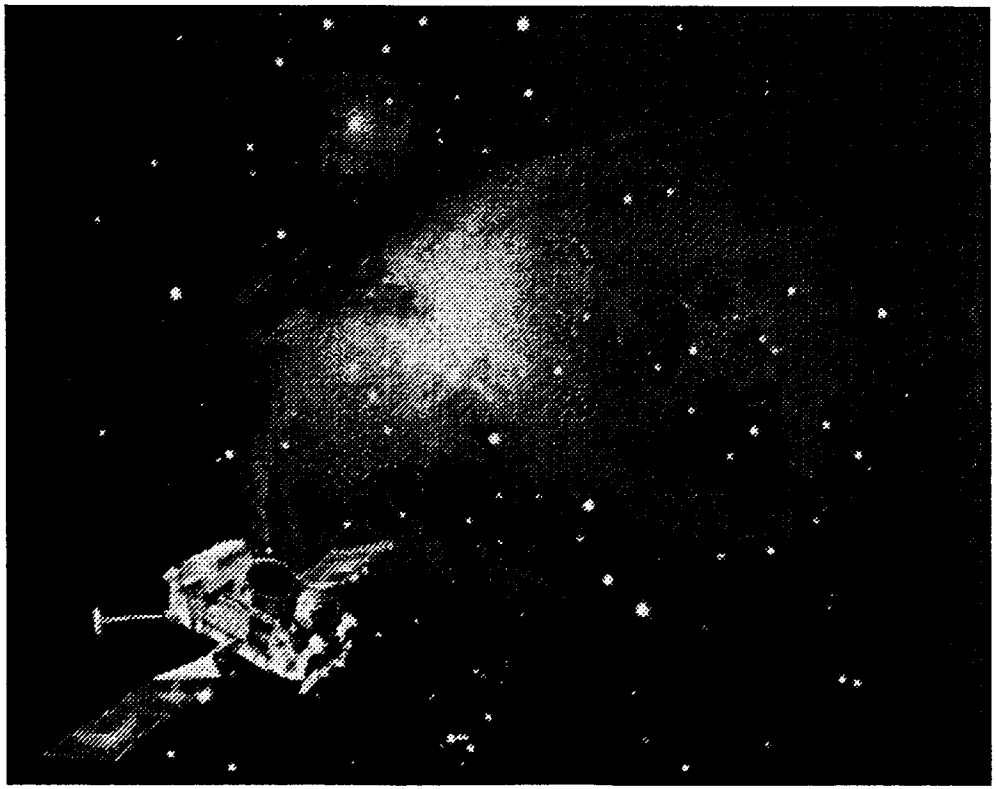
Thrust	Area	Element	Div	Accomplishment	POC	Ctr	Phone
	Information&Controls	Advanced Technology	RC	Multi-Flexible Body Dynamic Modeling Tools	John Sunkel	JSC	(713) 483-8591
		Breakthrough	RC	Photonic Devices for Planetary Lander	Max Reid	ARC	(415) 604-4378
	Human Support	Advanced Technology	RC	EVA Cuff check list functional mock-up	Barbara Woolford	JSC	(713) 483-3701
		Breakthrough	RC	Virtual Environment Facility	Creon Levitt	ARC	(415) 604-4403
	Space Communications	Advanced Technology	RC	AMT Mobile Communications	Tom Jedrey	JPL	(818) 354-5187
			RC	High Efficiency TWTA for Cassini	Gene Fujikawa	HQ	(202) 453-8999
	University Space		RS	First Terahertz Focal Plane Array	Gordon Johnston	HQ	(202) 453-2755
	Research		RS	Micro-Sensor for Flow Measurements	Gordon Johnston	HQ	(202) 453-2755
			RS	C02-to-Oxygen Demonstration Plant	Murray Hirshbein	HQ	(202) 453-2859
	Space Flight		RX	OARE	Dave Throckmorton	LaRC	(804) 864-4406
			RX	SILTS	Dave Throckmorton	LaRC	(804) 864-4406
	IN-STEP		RX	MODE: Middeck 0-G Dynamics Experiment	Lela Vann	HQ	(202) 453-1487
			RX	TPCE: Tank Pressure Control Experiment	John Landers	HQ	(202) 453-2835

SCIENCE

FOCUSSED PROGRAM

SCIENCE TECHNOLOGY

DEVELOP ADVANCED INSTRUMENT, OBSERVATION, INFORMATION, AND IN SITU MEASUREMENT TECHNOLOGIES TO MAXIMIZE THE RETURN FROM NASA SPACE AND EARTH SCIENCE MISSIONS OVER THE NEXT TWENTY YEARS



- EXPAND CAPABILITY AND REDUCE COSTS THROUGH DISCIPLINARY ADVANCEMENTS WHICH INCREASE SCIENCE INFORMATION RETURN AND SPACECRAFT PERFORMANCE
  - INSTRUMENT
  - OBSERVATION
  - DATA & INFORMATION
  - IN SITU MEASUREMENT
- ENABLE THE NEXT GENERATION OF SPACE SCIENCE MISSIONS
  - ASTROPHYSICS
  - SOLAR SYSTEM EXPLORATION
  - SPACE PHYSICS
  - EARTH SCIENCE
  - LIFE SCIENCES/MICROGRAVITY

Office of Aeronautics and Space Technology

HgZnTe 1 X 270 ARRAY

NASA = LaRC — OAST RC

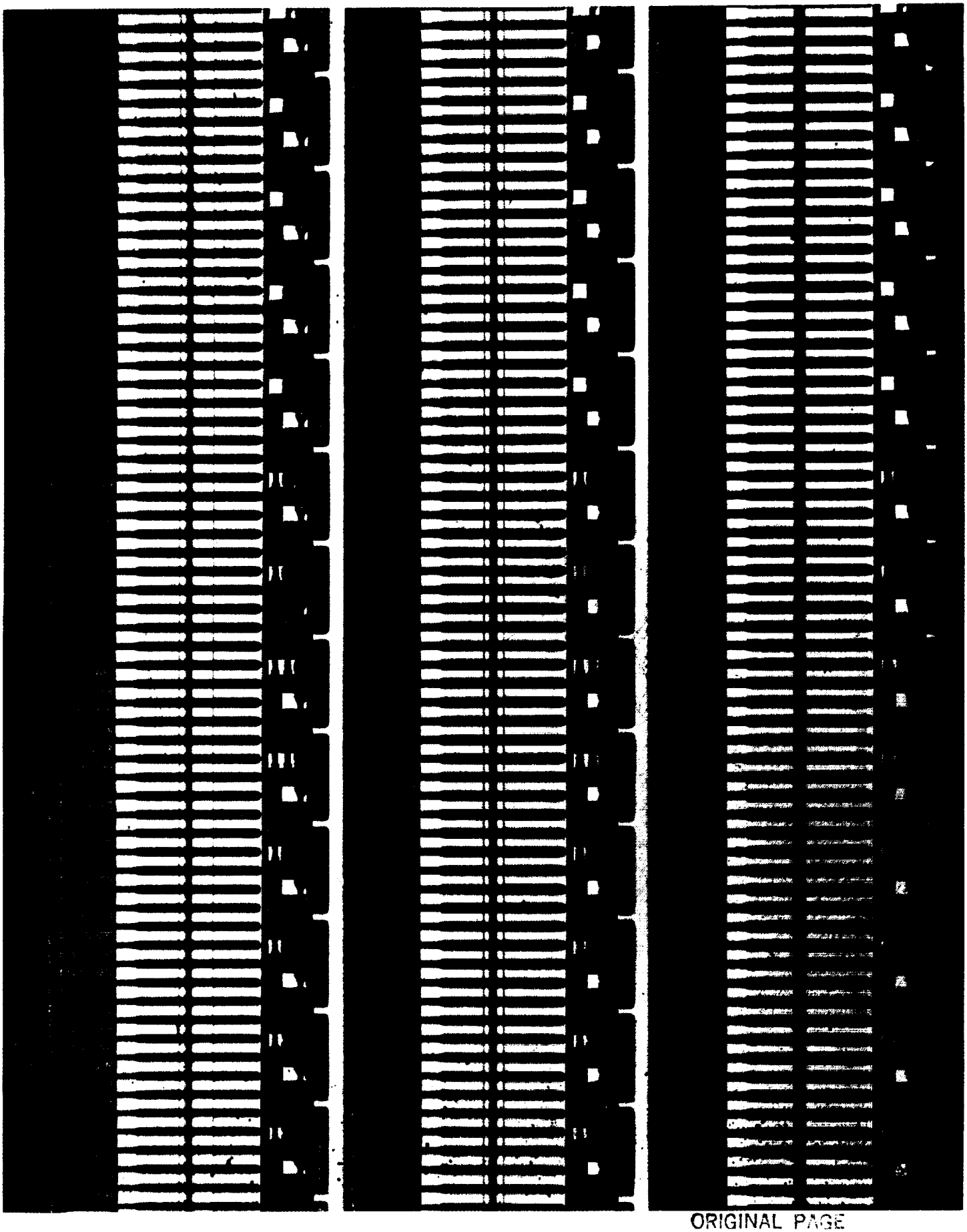
SHOWN
- MERCURY ZINC TELLURIDE (HgZnTe) 1 X 270 LINEAR ARRAY

OBJECTIVE
- TO DEVELOP HgZnTe INFRARED (IR) MATERIALS AND DEVICES HAVING IMPROVED ROBUSTNESS AND RELIABILITY FOR REMOTE SENSING IN THE FAR-IR (8-20 MICRON) SPECTRAL BANDS

ACCOMPLISHMENT
- DEMONSTRATED HIGH SENSITIVITY AND FAR-IR SPECTRAL RESPONSE ON TWO HgZnTe 1 X 270 ARRAYS (DEVELOPED IN FY90)
- COMPLETED COMPARATIVE VACUUM BAKE OF HgZnTe PHOTOCONDUCTIVE DEVICES WITH HgCdTe (MERCURY CADMIUM TELLURIDE) PHOTOCONDUCTIVE DEVICES
  - HgCdTe RESPONSIVITY DOWN >90% AFTER 1 WEEK AT 100°C; HgZnTe UNCHANGED
  - HgZnTe VACUUM BAKED FOR ANOTHER 21 DAYS WITH NEGLIGIBLE CHANGE
- DEVELOPED IMPROVED(BETTER SURFACE MORPHOLOGY AND FEWER INTERNAL DEFECTS) HgZnTe MATERIALS (DEVICES CURRENTLY IN FABRICATION PROCESS)

BENEFITS
- HgZnTe MATERIALS
  - ENABLE LONGER LIFE DEVICES BY PERMITTING EXTENDED HIGHER TEMPERATURE VACUUM BAKES
  - PERMITS HIGHER TEMPERATURE OPERATION AT 20 MICRONS COMPARED TO STATE-OF-THE-ART HgCdTe, THUS ENABLING LOWER COOLING REQUIREMENTS

APPLICABLE MISSIONS
- EOS ATMOSPHERIC INFRARED SOUNDER (AIRS)
- EOS MODERATE-RESOLUTION IMAGING SPECTROMETER-NADIR (MODIS-N)
- EOS SPECTROSCOPY OF THE ATMOSPHERE USING FAR-INFRARED EMISSIONS (SAFIRE)



SILICON-COMPATIBLE INFRARED SENSORS

NASA — JPL — OAST

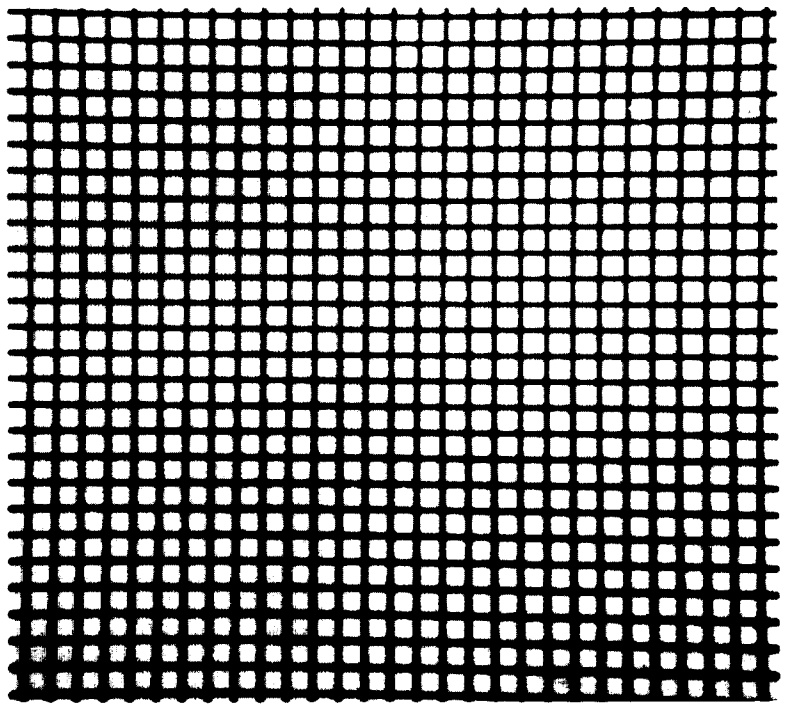
RC

SHOWN	● 128x128 SiGe/Si HETEROJUNCTION INTERNAL PHOTOEMISSION (HIP) SENSOR ARRAY
OBJECTIVE	● DEVELOP NEW INFRARED (2 TO 18 μm WAVELENGTHS) DETECTOR MATERIALS AND DEVICE STRUCTURES WHICH ARE SILICON-BASED, WILL OPERATE AT TEMPERATURES ABOVE 65° K, AND WHICH CAN BE FORMATTED INTO LARGE (i.e. MANY ELEMENT) ARRAYS FOR IMAGING AND SPECTROMETER APPLICATIONS
ACCOMPLISHMENT	● DEMONSTRATED 128x128 ARRAY OF HIP DETECTORS, SENSITIVE TO WAVELENGTHS FROM 2 TO 18 μm AT 40°K OPERATING TEMPERATURE
BENEFITS	● SENSOR ARRAYS OPERATING ABOVE 65° K DO NOT REQUIRE STORED CRYOGENS WHICH LIMIT MISSION LIFE ● WIDESPREAD COMMERCIAL USE OF KNOWN SILICON TECHNOLOGY (e.g. FOR RADIOS, TVs, COMPUTERS) WILL ENABLE SILICON-COMPATIBLE IR DETECTOR MATERIALS TO BE PRODUCED AT LOW COST
APPLICABLE MISSIONS	● EOS AND EOS FOLLOW-ON THERMAL IR INSTRUMENTS (e.g. AIRS, MODIS) ● PLANETARY MISSIONS

SILICON-COMPATIBLE INFRARED SENSORS

- Demonstrated the first SiGe long wavelength infrared sensor (>22 μm) using molecular beam epitaxy
- Fabricated 128 x 128 sensor arrays with a 18 μm cutoff wavelength

Silicon wafer with 128 x 128 LWIR sensor arrays and test devices



Pixels of the LWIR sensor array with a 60 μm x 60 μm size

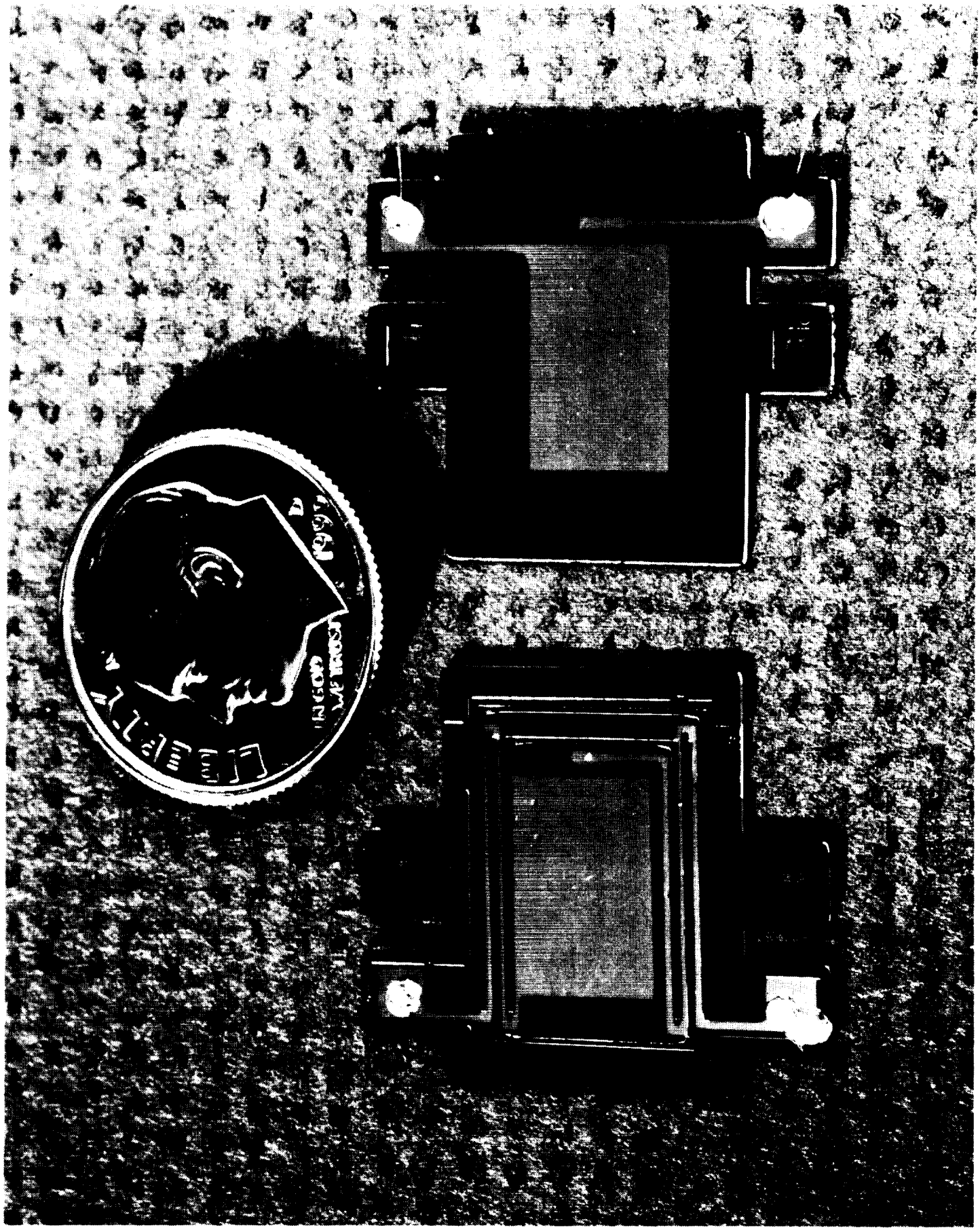
SILICON MICROMACHINED INFRARED TUNNEL SENSOR

NASA = JPL — OAST

RC

SHOWN	● PROTOTYPE TUNNELING INFRARED SENSOR
OBJECTIVE	● TO DEVELOP NEW INFRARED DETECTOR MATERIALS AND DEVICE STRUCTURES WITH EXTENDED WAVELENGTH RANGE (2 TO 18 μm WAVELENGTHS) WHICH ARE SILICON-BASED, WILL OPERATE AT TEMPERATURES ABOVE 65° K, AND WHICH CAN BE FORMATTED INTO LARGE (i.e. MANY ELEMENT) ARRAYS
ACCOMPLISHMENT	● BUILT AND CHARACTERIZED NOVEL SILICON-BASED TUNNELING INFRARED SENSOR ● INITIAL DEVICE DEMONSTRATED PERFORMANCE COMPARABLE TO STATE-OF-THE-ART (SOA) UNCOOLED INFRARED DETECTORS, EXPECT FUTURE DEVICES TO DEMONSTRATE 3-TO-5 FOLD IMPROVEMENT IN SENSITIVITY OVER SOA
BENEFITS	● SILICON-COMPATIBLE IR DETECTORS HAVE POTENTIAL FOR LOW COST, HIGHLY UNIFORM ARRAYS ● ENABLES BROAD-BAND MEASUREMENTS (AS OPPOSED TO OTHER APPROACHES WHICH ARE MORE SUITABLE FOR NARROW, HIGH SPECTRAL RESOLUTION OBSERVATIONS) - SENSOR USES EXPANSION OF TRAPPED GAS TO MEASURE ENERGY ABSORBED FROM INCOMING INFRARED RADIATION
APPLICABLE MISSIONS	● EOS AND EOS FOLLOW-ON INSTRUMENTS ● SOLAR PHYSICS MISSIONS ● PLANETARY MISSIONS

SCIENCE FY91



ORIGINAL PAGE
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GERMANIUM BLOCKED-IMPURITY-BAND(GeBIB) DETECTOR ARRAYS

NASA = JPL — OAST

RC

SHOWN
- 2x8 ELEMENT GeBIB ARRAY

OBJECTIVE
- TO DEVELOP FAR INFRARED (FIR, 30-250 μm WAVELENGTH) DETECTOR ARRAYS FOR FUTURE ASTROPHYSICS IMAGERS AND SPECTROMETERS, WITH HIGH SENSITIVITY, LOW BACKGROUND NOISE, AND HIGH RADIATION RESISTANCE

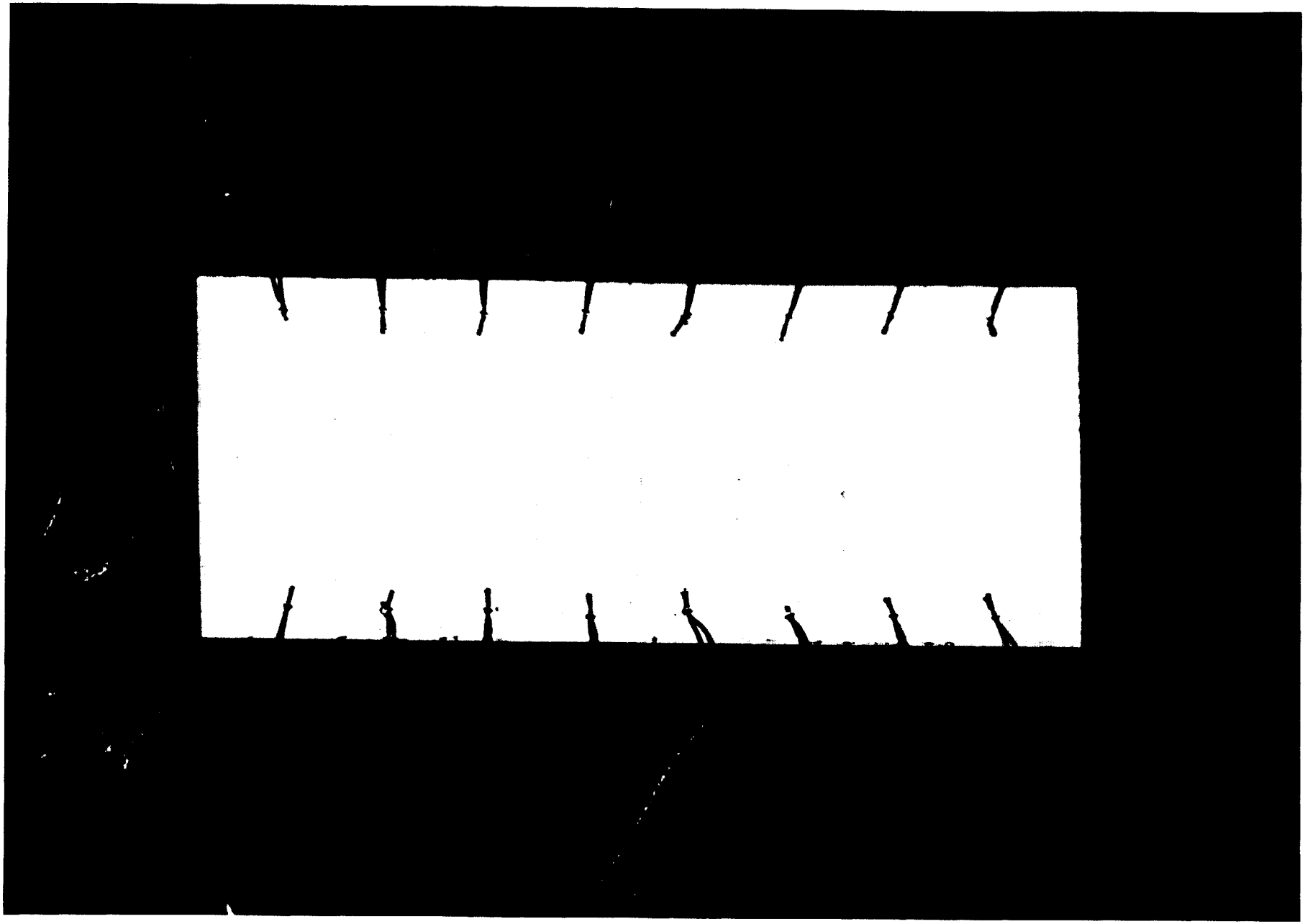
ACCOMPLISHMENT
- DEVELOPED AND DEMONSTRATED 2x8 FIR ARRAY
  - PERFORMANCE OF EACH ELEMENT IN ARRAY COMPARABLE WITH PREVIOUS GeBIB SINGLE ELEMENT DETECTORS
  - 50-190 μm WAVELENGTH RANGE AT 1.4° K OPERATING TEMPERATURE

BENEFITS
- ARRAY CAPABILITY PROVIDES IMPROVED SPATIAL AS WELL AS SPECTRAL RESOLUTION, WHILE PRESERVING SENSITIVITY AND LOW BACKGROUND NOISE OF PREVIOUS SINGLE ELEMENT DETECTORS
- GeBIB DETECTORS, COMPARED TO CURRENT STATE-OF-THE-ART (SOA) SINGLE ELEMENT TECHNOLOGY FOR FIR MEASUREMENTS,
  - ENABLE OPERATION AT HIGHER TEMPERATURES (1.4°K vs. 0.1° to 0.3°K), REQUIRING SUBSTANTIALLY LESS ON-BOARD CRYOGENIC COOLING FLUID
  - ENABLE RADIATION HARDNESS FOR INCREASED SENSITIVITY
  - ENABLE ARRAY FORMAT

  (SOA ACHIEVES SENSITIVITY BY EITHER OPERATING AT MUCH LOWER TEMPERATURES OR BY USING A DESIGN THAT IS INTOLERANT OF NATURAL SPACE BACKGROUND RADIATION)

APPLICABLE MISSIONS
- SIRTF
- SMIM
- LDR

SCIENCE FY91



SUPERCONDUCTOR-INSULATOR-SUPERCONDUCTOR (SIS) MIXER ELEMENTS

SHOWN

- 2x5 ELEMENT FOCAL PLANE ARRAY OF DIPOLE ANTENNAS WITH SIS TUNNEL JUNCTIONS (SIS TUNNEL JUNCTIONS TOO SMALL TO BE SEEN IN PHOTO)

OBJECTIVE

- TO DEVELOP HIGH SENSITIVITY, HIGH FREQUENCY SIS MIXER ELEMENTS FOR USE IN SUBMILLIMETER WAVE HETERODYNE RADIOMETERS

ACCOMPLISHMENT

- ACHIEVED MAJOR BREAKTHROUGHS IN 3 AREAS WITH SIS TUNNEL JUNCTION MIXER ELEMENTS
  - DEMONSTRATED SENSITIVITY APPROACHING THEORETICAL PERFORMANCE (FACTOR OF 20 AWAY) AT EXTREMELY HIGH FREQUENCY (500 GHz)
  - DEMONSTRATED CLOSER THEORETICAL PERFORMANCE (FACTOR OF 5 AWAY) AT MODERATE FREQUENCY (200 GHz)
  - DEVELOPED 2x5 ELEMENT SIS FOCAL PLANE ARRAY WHICH WILL ENABLE 2-DIMENSIONAL IMAGING

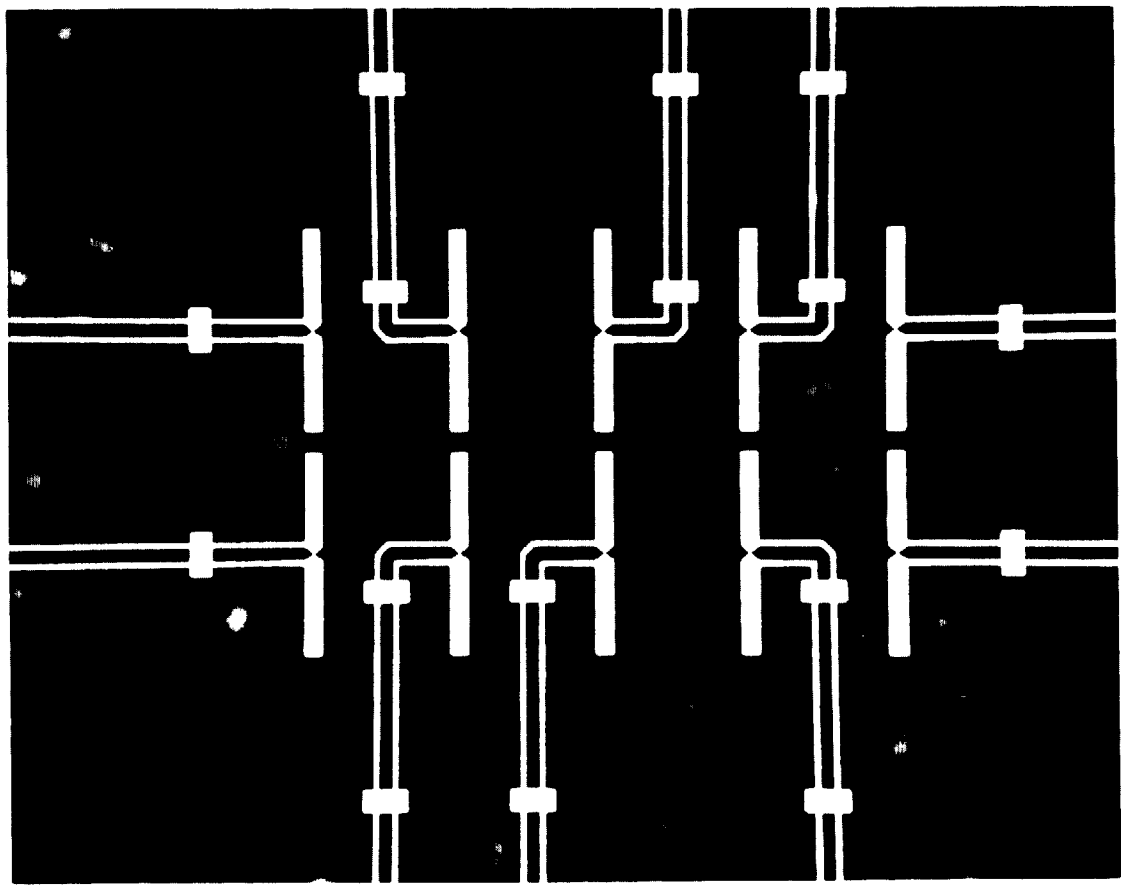
BENEFITS

- SUBMILLIMETER ASTROPHYSICS OBSERVATIONS ENABLE CRITICAL MEASUREMENTS OF CHEMICAL SPECIES IN DISTANT INTERSTELLAR GAS CLOUDS
- SIS MIXER ELEMENTS PROVIDE THE HIGHEST SENSITIVITY HETERODYNE RADIOMETERS IN THE SUBMILLIMETER WAVELENGTHS

APPLICABLE MISSIONS

- SUBMILLIMETER INTERMEDIATE MISSION (SMIM)
- LARGE DEPLOYABLE REFLECTOR (LDR)

Nb/AlO$_x$/Nb 230 GHz DIPOLE ARRAY



H. LeDuc and P. Siegel (JPL) 1991

2-MICRON LASER FOR LIDAR (LIGHT DETECTION AND RANGING)

NASA — LaRC — OAST

RC

SHOWN

- 2 MICRON SOLID STATE LASER CRYSTAL MOUNTED ON THERMOELECTRIC CHILLER (CRYSTAL IS SMALL CUBE ON TOP)

OBJECTIVE

- TO IMPROVE PERFORMANCE OF KNOWN SOLID STATE LASER MATERIALS AND CHARACTERIZE CANDIDATE NEW SOLID-STATE LASER MATERIALS

ACCOMPLISHMENT

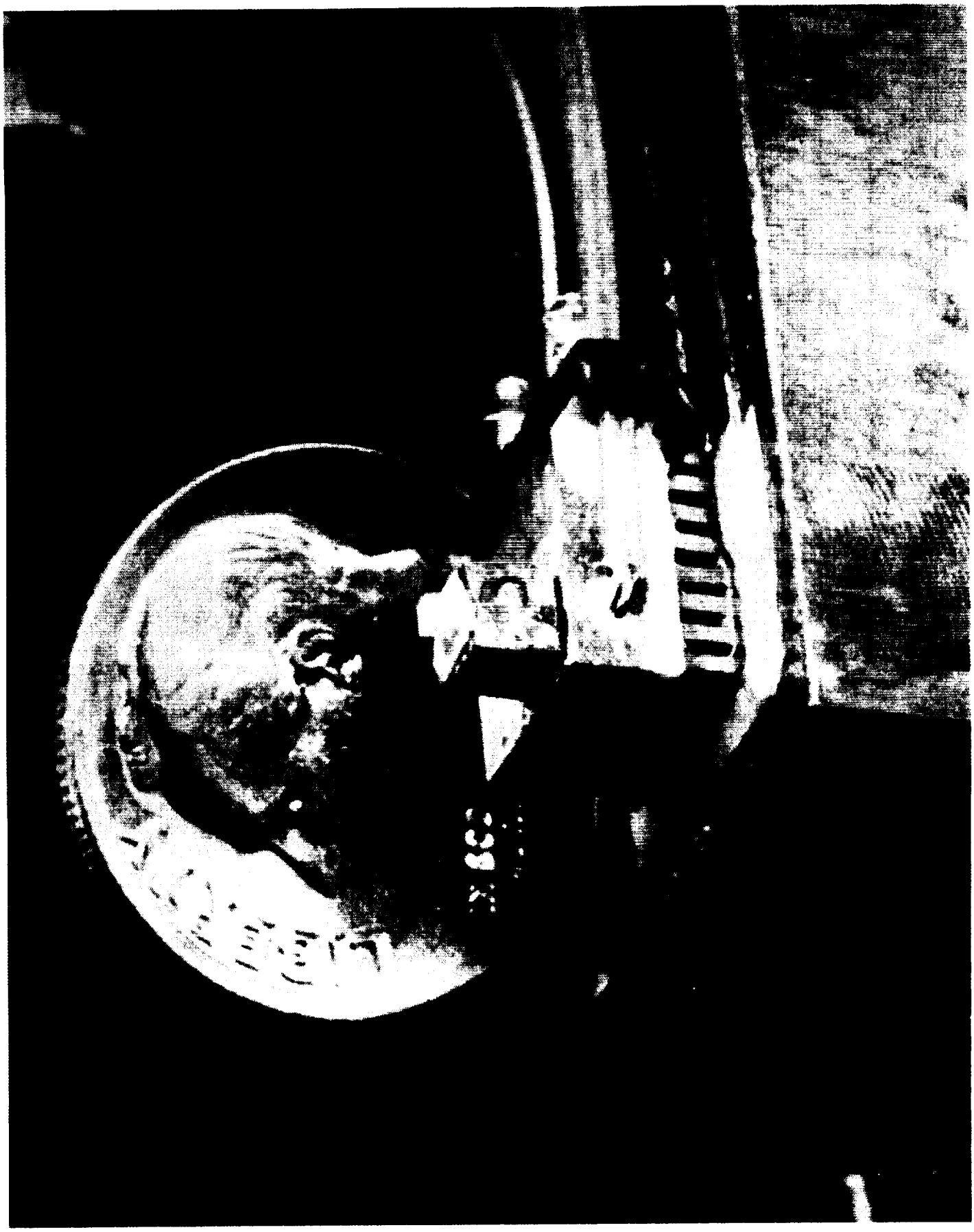
- DEMONSTRATED IMPROVED PERFORMANCE IN TWO 2-MICRON SOLID STATE LASER MATERIALS
  - IMPROVED EFFICIENCY AND SPECTRAL PURITY IN HOLMIUM, THULIUM DOPED YTTRIUM ALUMINUM GARNET (Ho, Tm: YAG) LASER
  - VERIFIED 13% OVERALL EFFICIENCY OF HOLMIUM, THULIUM DOPED YTTRIUM LITHIUM FLUORIDE (Ho, Tm: YLF) LASER AT ROOM TEMPERATURE

BENEFITS

- ENABLES BROAD VARIETY OF OBSERVATIONS OF THE EARTH FROM SPACE, INCLUDING WIND SPEEDS, ATMOSPHERIC TRACE GASSES, AND ACCURATE RANGING TO SURFACES, ICE SHEETS, AND CLOUD TOPS
- MORE RELIABLE, MORE EFFICIENT, REDUCED SIZE AND MASS COMPARED TO STATE-OF-THE-ART LASERS
  - GREATER OUTPUT POWER FOR REDUCED INPUT POWER
  - IMPROVED LIDAR RANGE AND SENSITIVITY FOR MORE ACCURATE MEASUREMENTS

APPLICABLE MISSIONS

- 2ND GENERATION EOS LAWS (LASER ATMOSPHERIC WIND SOUNDER)
- FUTURE LIDAR AND DIAL (DIFFERENTIAL ABSORPTION LIDAR) MISSIONS
- PLANETARY MISSIONS



MICRODYNAMIC COMPONENT TESTER (MCT)

NASA — JPL — OAST

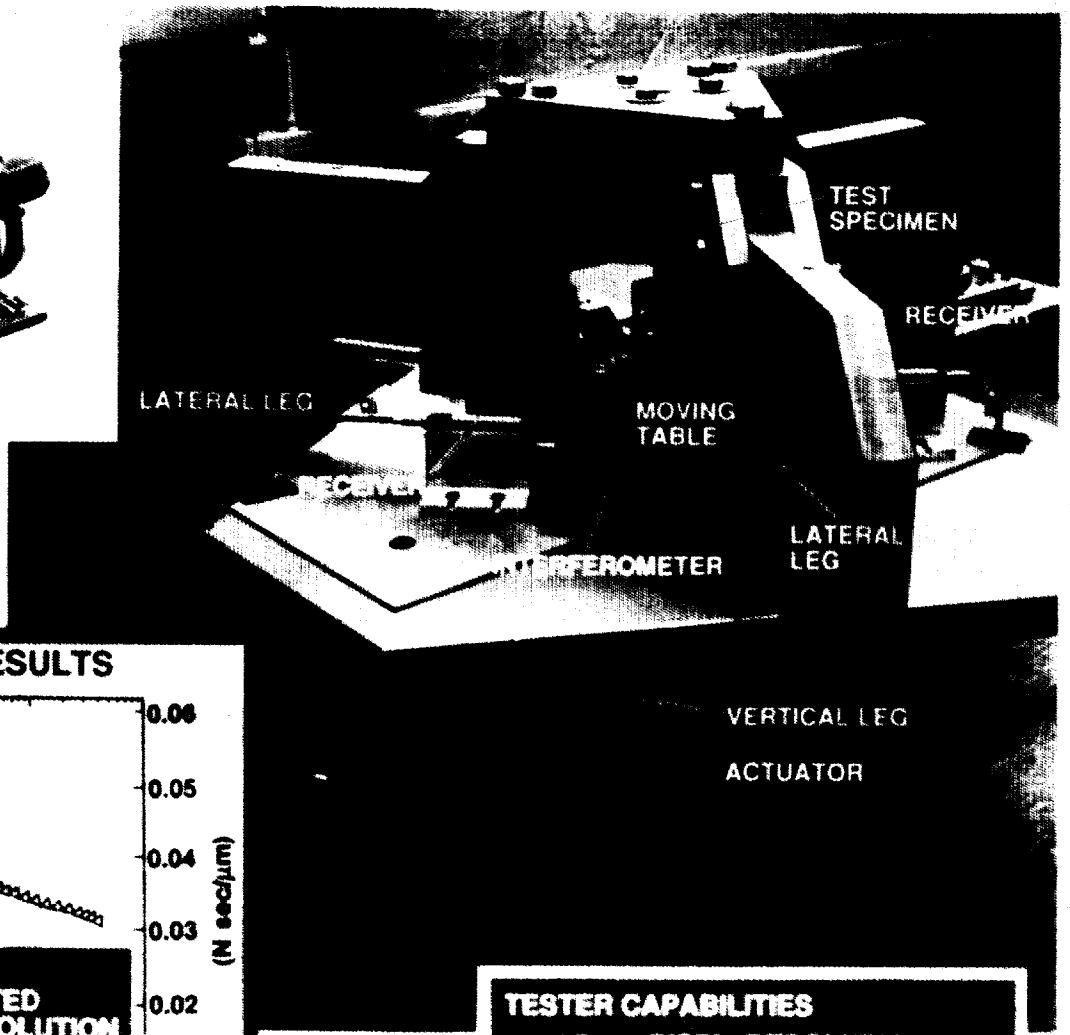
RM

SHOWN	● MICRODYNAMIC COMPONENT TESTER, MCT CAPABILITIES, PASSIVE DAMPER COMPONENT, DAMPER TEST RESULTS
OBJECTIVE	● TO DEVELOP A COMPONENT TESTING CAPABILITY FOR MICROPRECISION SYSTEM COMPONENT PERFORMANCE AT THE NANOMETER LEVEL ● TO GENERATE NANOMETER-REGIME DATA ON THE STIFFNESS OR DAMPING BEHAVIOR OF MICRODYNAMIC STRUCTURES, JOINTS, AND ACTUATORS
ACCOMPLISHMENT	● COMPLETED MICRODYNAMIC COMPONENT TESTER WITH 1.25 NANOMETER DISPLACEMENT AND 20 MICRONEWTONS FORCE RESOLUTION ● DEMONSTRATED LINEAR VISCOUS DAMPING AT 15 NANOMETER RESOLUTION USING THE MICRODYNAMIC COMPONENT TESTER
BENEFITS	● ENABLES VALIDATION OF THE PERFORMANCE OF MICRO-PRECISION SYSTEM COMPONENTS (e.g., STRUCTURAL MEMBERS, JOINTS, DAMPERS, ACTUATORS, NEW MATERIALS) IN THE NANOMETER REGIME ● ENABLES THE GENERATION OF AN EXTENSIVE MICRODYNAMICS DATABASE FOR DESIGNERS OF FUTURE OPTICAL CLASS SPACE SYSTEMS ● REPRESENTS A NATIONAL RESOURCE FOR INVESTIGATORS OF THE MICRODYNAMIC PROPERTIES OF MATERIALS AND COMPONENTS
APPLICABLE MISSIONS	● OSI ● POINTS ● NEXT GENERATION SPACE TELESCOPE ● IMAGING INTERFEROMETER

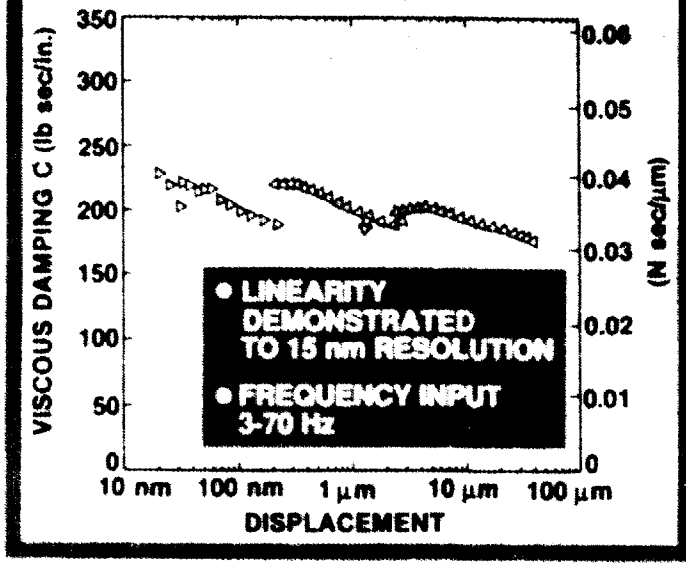
SCIENCE FY91

JPL MICRODYNAMIC COMPONENT TESTER

D-STRUT
PASSIVE DAMPER



D-STRUT TEST RESULTS



TESTER CAPABILITIES

- 1.2 nm DISPL. RESOLUTION
- 20 μ-N FORCE RESOLUTION
- 6 DEGREE OF FREEDOM MOTION
- 0-70 Hz FREQUENCY RESPONSE
- COMPUTER CONTROLLED

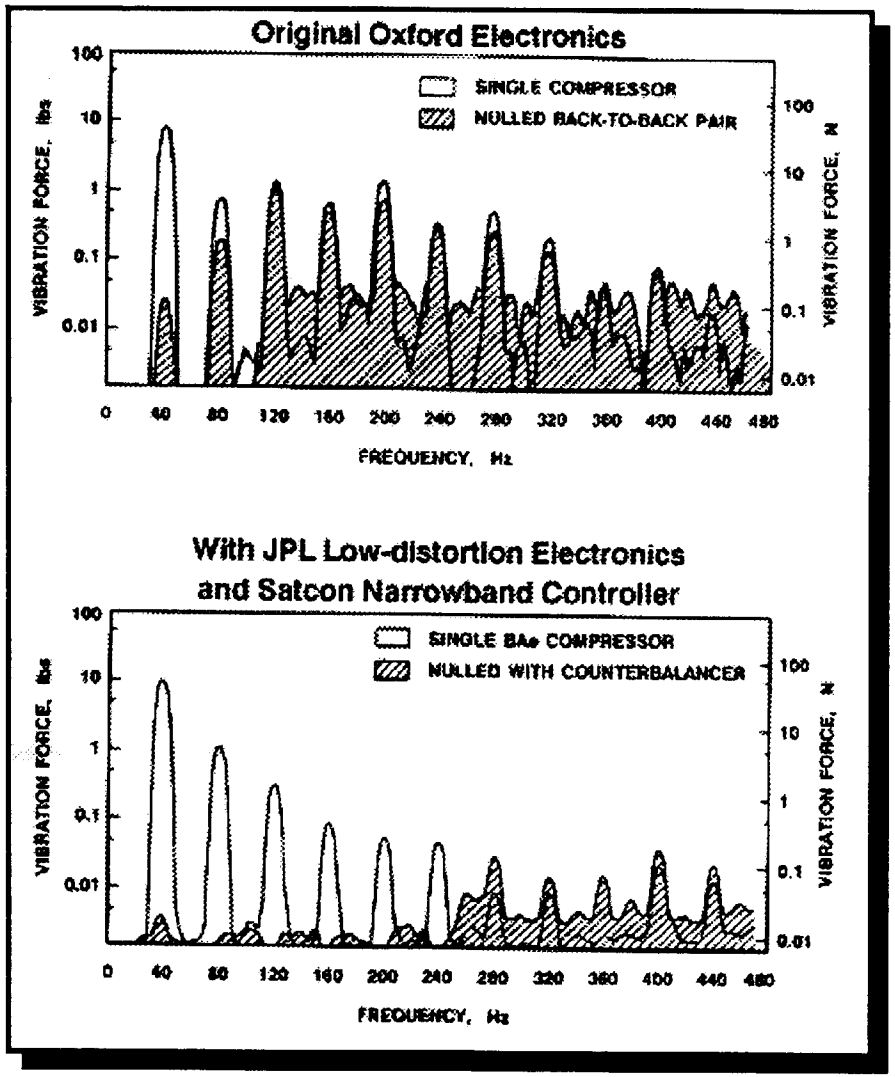
LOW-VIBRATION STIRLING-CYCLE COOLER

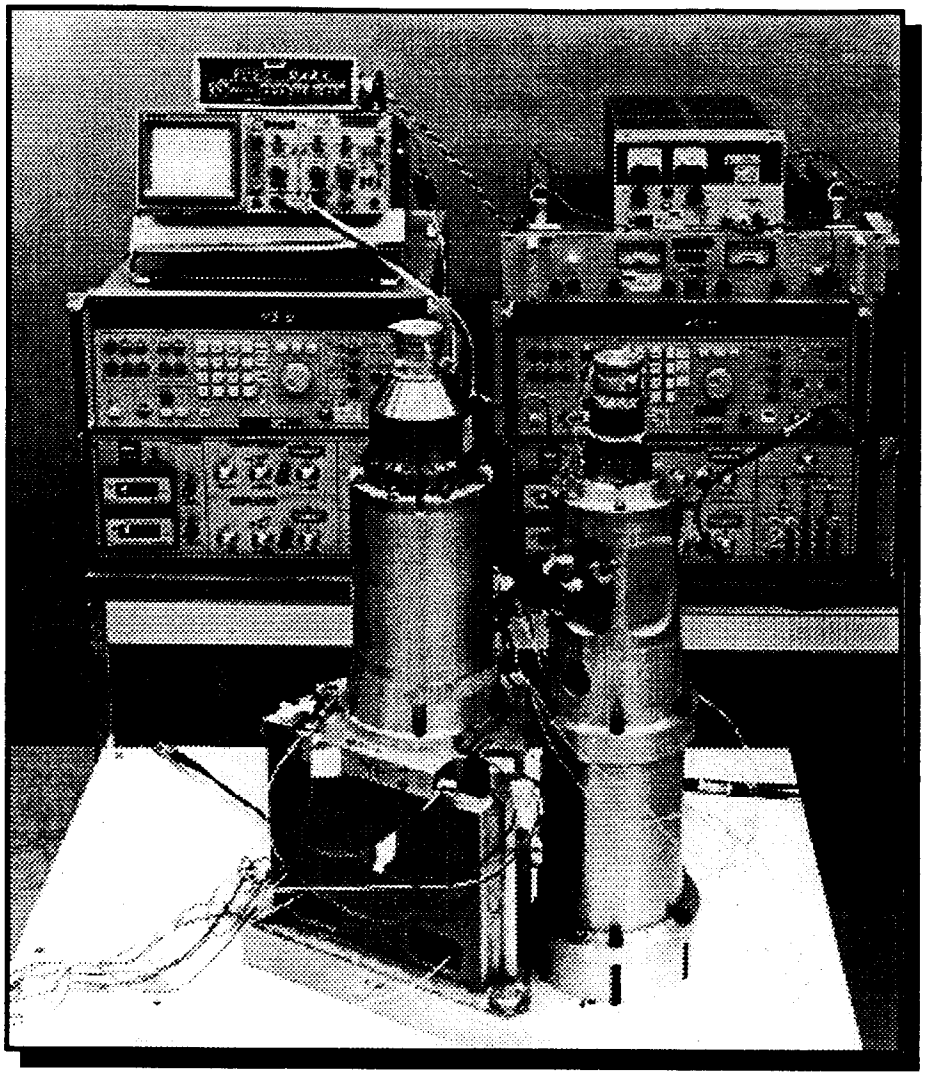
NASA — JPL — OAST

RC

SHOWN	● TESTING OF ADVANCED VIBRATION CONTROL ELECTRONICS WITH BACK-TO-BACK BRITISH AEROSPACE (BAe) COOLERS ON JPL 6-DEGREE-OF-FREEDOM VIBRATION DYNAMOMETER
OBJECTIVE	● TO REDUCE VIBRATION GENERATED BY STIRLING-CYCLE CRYOCOOLERS TO LESS THAN 0.05 LBS OF FORCE
ACCOMPLISHMENT	● ACHIEVED GREATLY REDUCED VIBRATION OF BRITISH AEROSPACE STIRLING-CYCLE COOLER USING NEW LOW-DISTORTION ELECTRONICS WITH MULTIPLE-HARMONIC NARROW-BAND VIBRATION CONTROL TECHNIQUES
BENEFITS	● 1000X DECREASE IN GENERATED VIBRATION (FROM 2 LBS TO 0.002 LBS) ● REDUCES INSTRUMENT JITTER ● IMPROVES SPECTROMETER RESOLUTION
APPLICABLE MISSIONS	● EARTH OBSERVING SYSTEM (EOS) INSTRUMENTS (AIRS, HRDLS, TES, SAFIRE) ● ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF) ● HIGH ENERGY SOLAR PHYSICS (HESP) GAMMA-RAY SPECTROMETERS

VIBRATION REDUCTION ACHIEVEMENTS WITH IMPROVED COOLER ELECTRONICS





BACK-TO-BACK BAe COOLERS ON JPL 6-DOF FORCE DYNAMOMETER

92-8037

ACOUSTO-OPTICAL TUNED FILTER (AOTF)-BASED IMAGING SPECTROMETER

NASA = JPL — OAST

RM

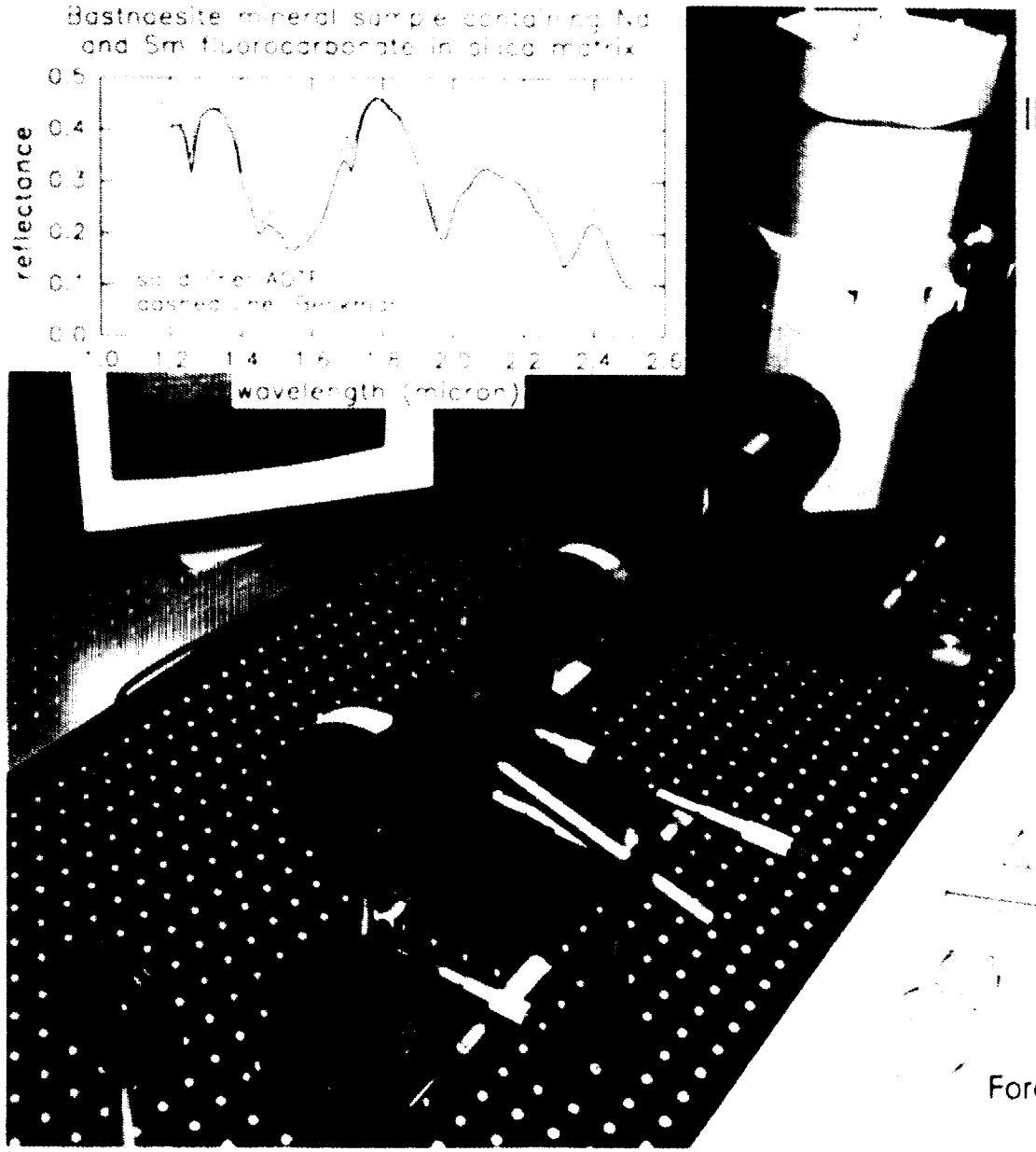
SHOWN
- ACOUSTO-OPTICAL TUNED FILTER (AOTF)-BASED IMAGING SPECTROMETER

OBJECTIVE
- TO DEVELOP BREADBOARD IMAGING SPECTROMETER IN THE VISIBLE AND NEAR INFRARED (IR) RANGE BASED ON AOTF TECHNOLOGY

ACCOMPLISHMENT
- DEMONSTRATED VISIBLE AOTF-BASED IMAGING SPECTROMETER WHICH WAS CONSTRUCTED IN FY90
- CONSTRUCTED AND DEMONSTRATED IR AOTF-BASED IMAGING SPECTROMETER BREADBOARD

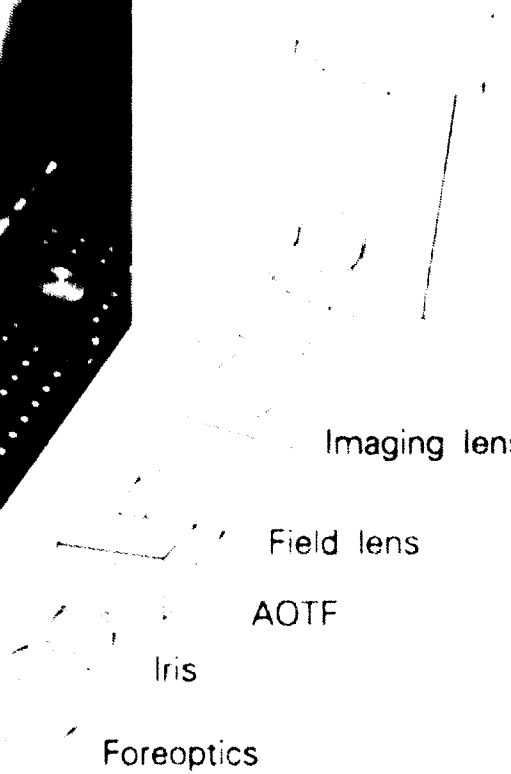
BENEFITS
- AOTF-BASED IMAGING SPECTROMETERS, WHEN COUPLED WITH HIERARCHICAL CLASSIFIER SOFTWARE, CAN IDENTIFY SCIENTIFICALLY VALUABLE GEOLOGIC MATERIAL FOR SUBSEQUENT COLLECTION 10-50X FASTER THAN CONVENTIONAL IMAGING SPECTROMETERS
  - ELIMINATES THE MECHANICAL SCANNING
  - STRATEGICALLY SELECTS WAVELENGTHS TO IDENTIFY THE GEOLOGIC MATERIALS
- REQUIRES UP TO 20X LESS MEMORY DUE TO STRATEGIC WAVELENGTH SELECTION

APPLICABLE MISSIONS
- MARS SAMPLE RETURN
- COMET NUCLEUS SAMPLE RETURN
- LUNAR SAMPLE RETURN



1.2-2.5 MICRON AOTF IMAGING SPECTROMETER BREADBOARD

HgCdTe detector array
in liquid nitrogen dewar

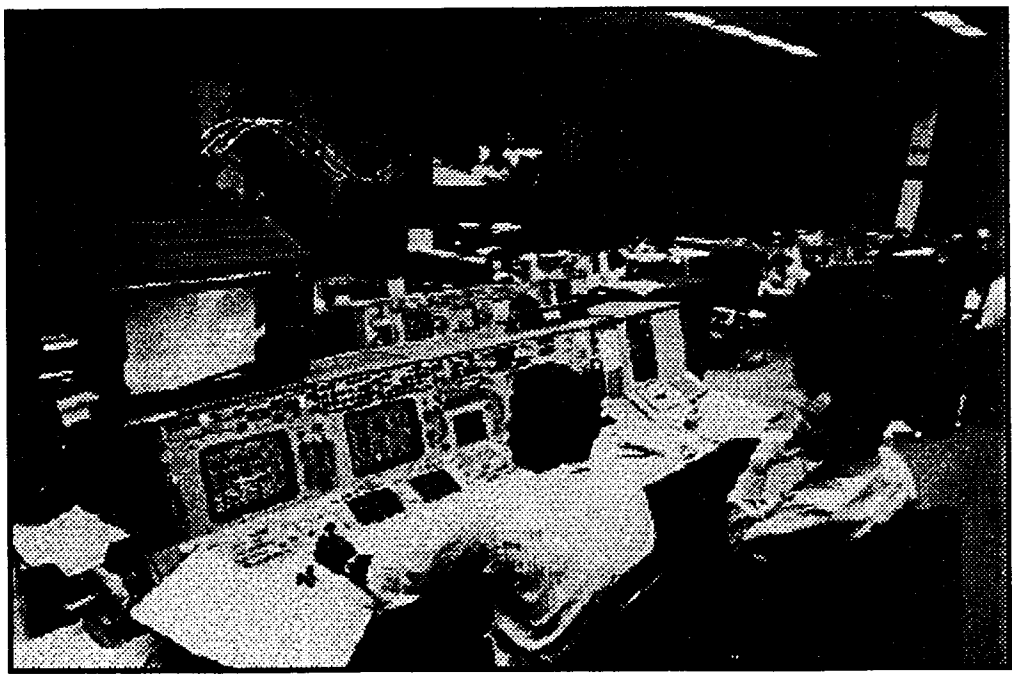


OPERATIONS

FOCUSSED PROGRAM

OPERATIONS TECHNOLOGY

DEVELOP AND DEMONSTRATE TECHNOLOGIES TO REDUCE THE COST OF NASA OPERATIONS, IMPROVE THE SAFETY AND RELIABILITY OF THOSE OPERATIONS, AND ENABLE NEW, MORE COMPLEX ACTIVITIES TO BE UNDERTAKEN



- THE OPERATIONS THRUST SUPPORTS THE FOLLOWING MAJOR ACTIVITIES:
  - IN-SPACE OPERATIONS
  - FLIGHT SUPPORT OPERATIONS
  - GROUND SERVICING AND PROCESSING
  - PLANETARY SURFACE OPERATIONS
  - COMMERCIAL COMMUNICATIONS
- THE FOLLOWING TECHNOLOGY AREAS ARE INCLUDED:
  - AUTOMATION & ROBOTICS
  - INFRASTRUCTURE OPERATIONS
  - INFORMATION & COMMUNICATIONS
  - FLIGHT EXPERIMENTS

Office of Aeronautics and Space Technology

91-8055

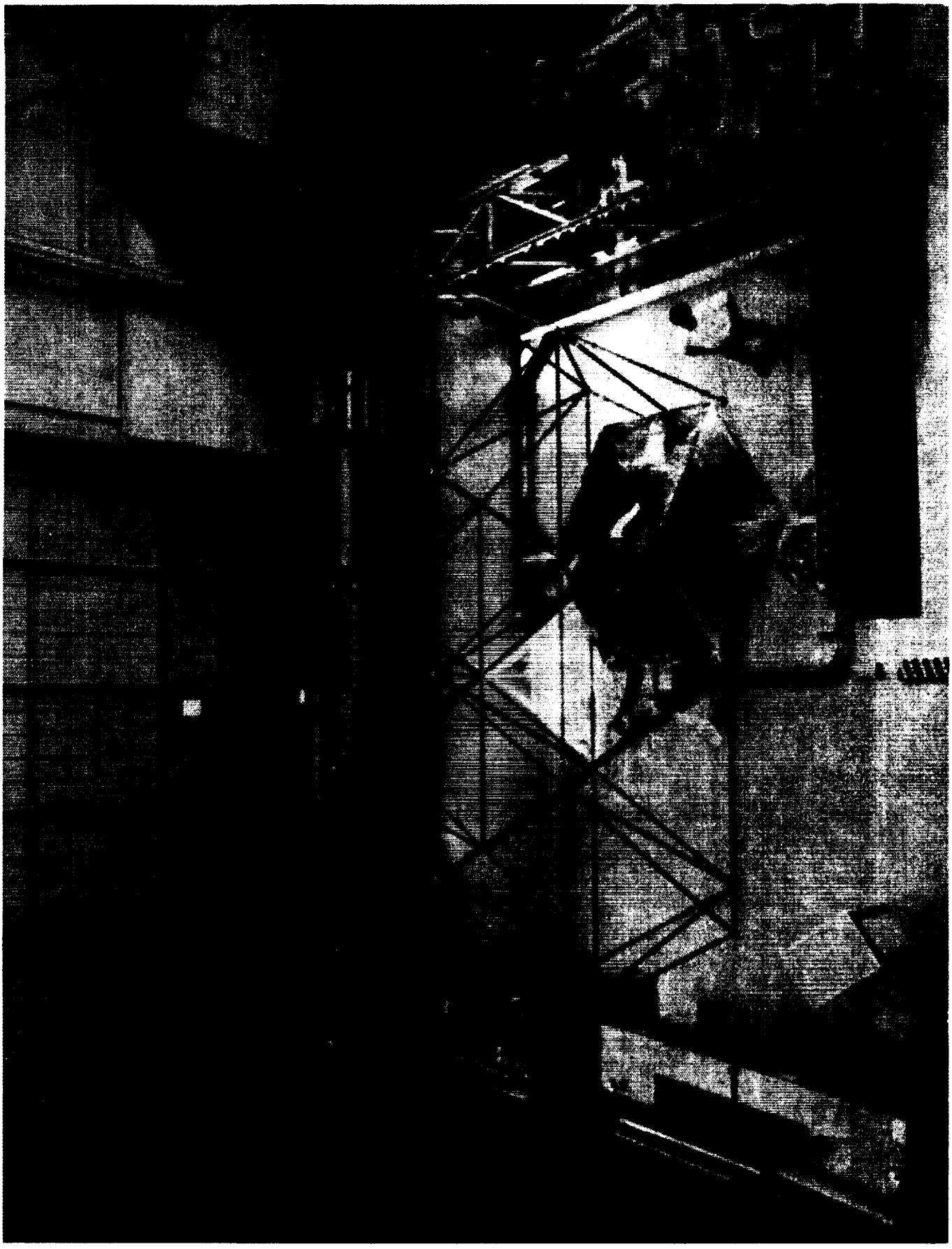
AUTOMATED ASSEMBLY OF SPACE STRUCTURES

NASA = LaRC — OAST

RC

SHOWN	● ROBOT ASSEMBLING TETRAHEDRAL TRUSS STRUCTURE IN THE LANGLEY RESEARCH CENTER AUTOMATED STRUCTURAL ASSEMBLY LABORATORY (ASAL)
OBJECTIVE	● TO DEMONSTRATE TELEROBOTIC METHODS FOR IN-SPACE ASSEMBLY OF LARGE SPACE STRUCTURES ● TO CHARACTERIZE ASSEMBLY HARDWARE CONCEPTS, CONSTRUCTION METHODS, AND COMPUTER ARCHITECTURES FOR SPACE OPERATIONS
ACCOMPLISHMENT	● DEMONSTRATED AUTOMATED ASSEMBLY AND DISASSEMBLY OF 107-ELEMENT PLANAR TRUSS STRUCTURE ● CHARACTERIZED SYSTEM PERFORMANCE, ASSEMBLY TECHNIQUES, AND TECHNOLOGY LIMITATIONS
BENEFITS	● IDENTIFIES PROBLEMS AND CONSTRAINTS ASSOCIATED WITH IN-SPACE CONSTRUCTION ● POTENTIAL 100% REDUCTION OF EXTRA-VEHICULAR ACTIVITY (EVA) REQUIREMENTS FOR CONSTRUCTION OF SPACE STRUCTURES
APPLICABLE MISSIONS	● PRECISION SEGMENTED REFLECTOR ● LARGE APERTURE SPACE OBSERVATORIES ● SPACE STATION FREEDOM

OPERATIONS FY91



ADVANCED TELEOPERATION

NASA — JPL — OAST

RC

SHOWN

- DIAGONAL CUTTERS FOR REMOVING PLASTIC TIE WRAPS ON WIRE BUNDLES DURING SIMULATED SOLAR MAX SATELLITE REPAIR (SMSR) EXPERIMENTS AT THE JPL ADVANCED TELEOPERATION LABORATORY

OBJECTIVE

- TO DEMONSTRATE AND EVALUATE APPLICATION OF DUAL-ARM ADVANCED TELEOPERATION TO SMSR SUBTASKS

ACCOMPLISHMENT

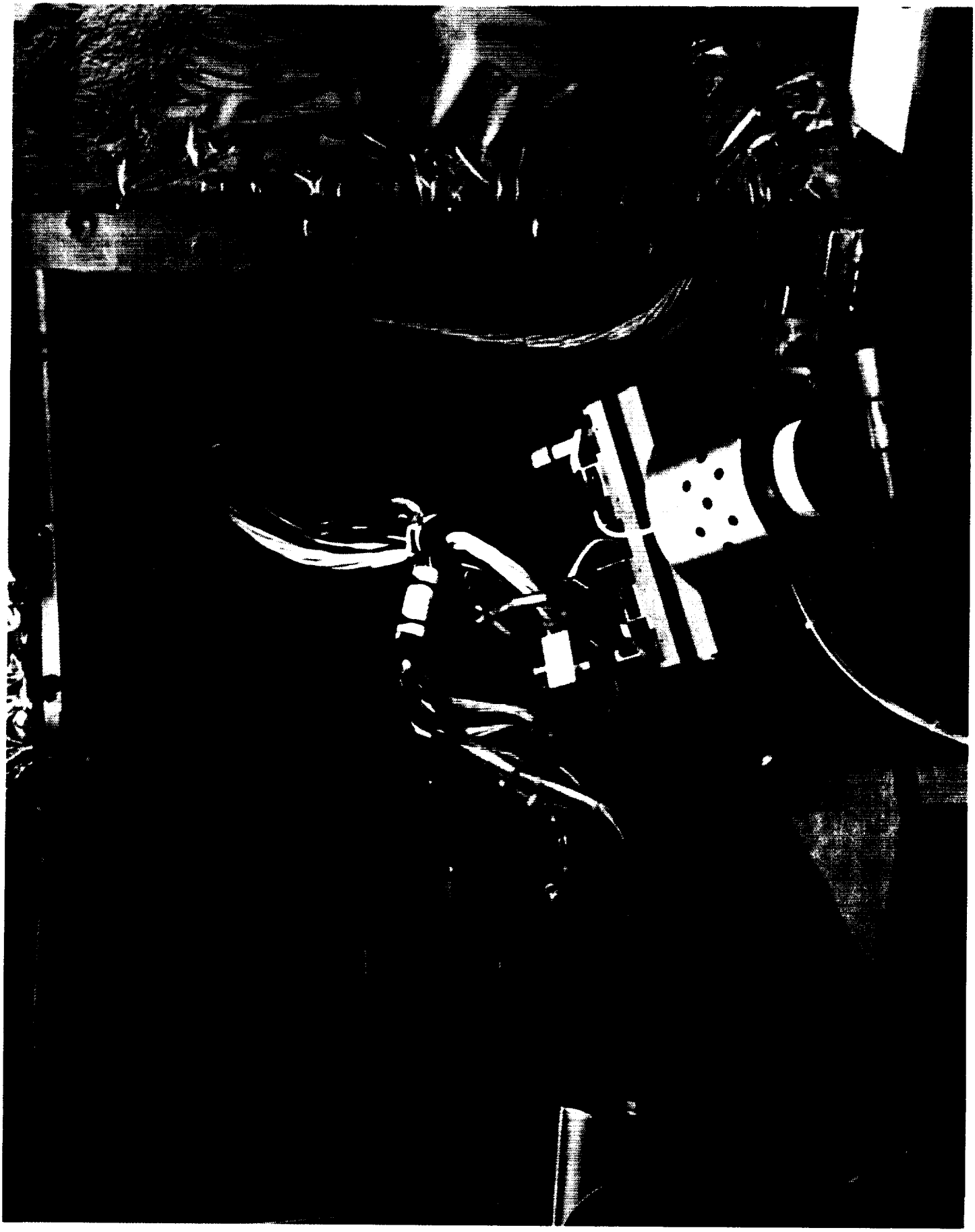
- DEMONSTRATED SIX OF TWELVE SMSR SUBTASKS:
  - CUTTING THERMAL BLANKET
  - UNBOLTING AND REBOLTING MAIN ELECTRONICS BOX
  - CUTTING PLASTIC TIE WRAPS ON WIRE BUNDLES
  - UNPLUGGING AND REPLUGGING ELECTRICAL CONNECTORS
- EVALUATED SYSTEM PERFORMANCE USING ALTERNATIVE CONTROL MODES (POSITION, RATE, MANUAL FORCE FEEDBACK, AUTOMATIC COMPLIANCE CONTROL) AND ALTERNATIVE VISUAL SYSTEMS

BENEFITS

- PROVIDES DATABASE OF ADVANCED TELEOPERATOR PERFORMANCE OF REALISTIC TASKS
- IDENTIFIES SPECIFIC DEVELOPMENT NEEDS FOR SPACE TELEOPERATION TASKS
- IDENTIFIES SPACE SERVICING TASKS AND CAPABILITIES APPROPRIATE FOR ADVANCED TELEOPERATION AS AN ALTERNATIVE TO HUMAN EVA

APPLICABLE MISSIONS

- REMOTE SERVICING AND REPAIR
- REMOTE SURFACE INSPECTION
- REMOTE CONSTRUCTION



ASTRONAUT SCIENCE ADVISOR

NASA — ARC — OAST — RC

SHOWN

- SLS-1 ROTATING DOME EXPERIMENT (UPPER LEFT), ASTRONAUT SCIENCE ADVISOR USER INTERFACE SHOWING ROTATING DOME DATA ON LEFT AND EXPERIMENT PROTOCOL ON RIGHT (LOWER LEFT), GROUND TESTING OF ASTRONAUT SCIENCE ADVISOR DURING SLS-1 MISSION (LOWER RIGHT)

OBJECTIVE

- DEVELOP ARTIFICIAL INTELLIGENCE (AI)-BASED ADVISORY SYSTEM FOR IN-FLIGHT USE BY ASTRONAUTS WITH SCIENTIFIC SPACE EXPERIMENTS

ACCOMPLISHMENT

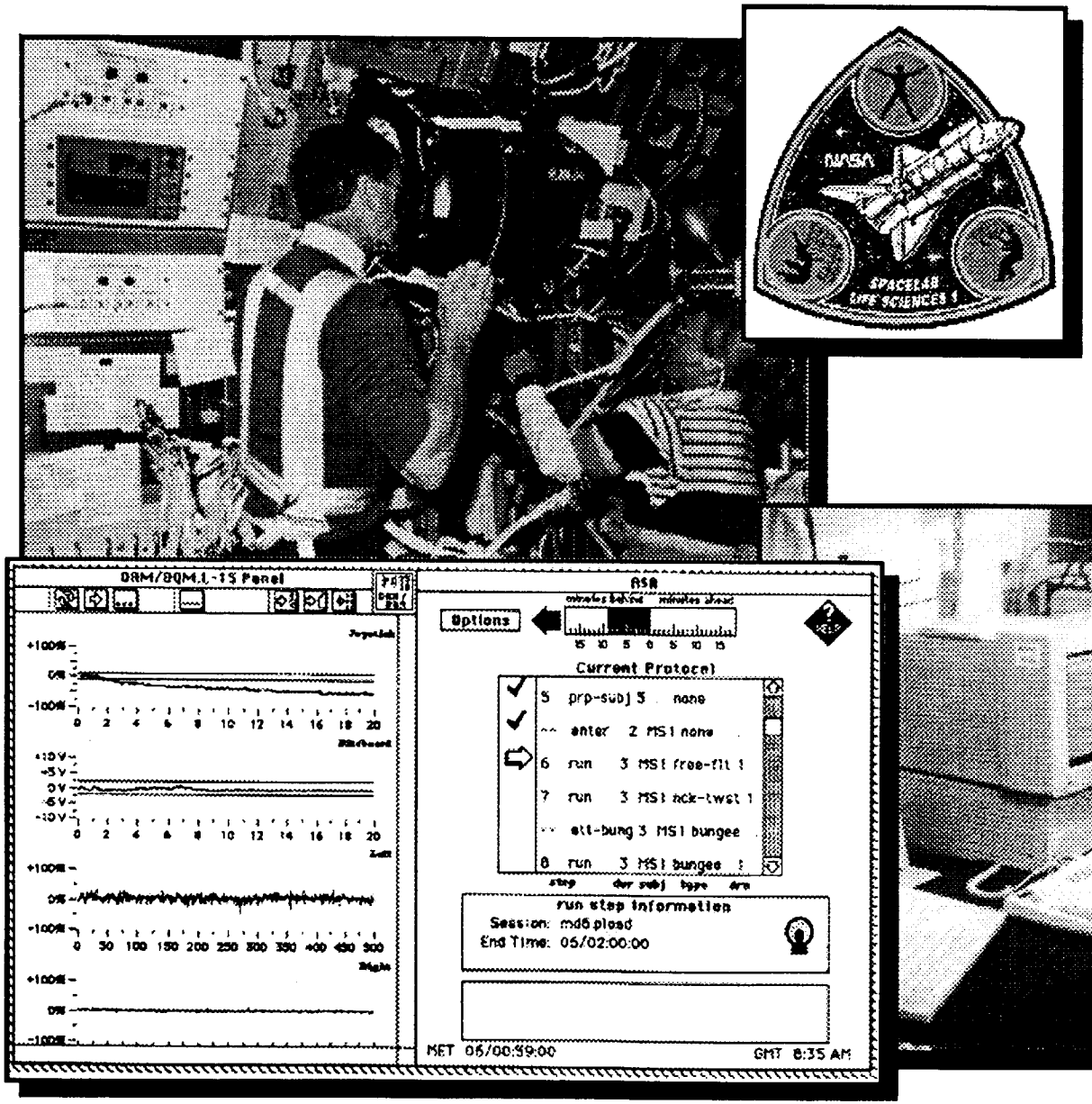
- COMPLETED SUCCESSFUL GROUND TEST OF ADVISORY SYSTEM DURING SPACELAB LIFE SCIENCES MISSION (SLS-1)
  - COLLECTED AND ANALYZED REAL-TIME DATA
  - SUGGESTED USEFUL EXPERIMENT PROTOCOL MODIFICATIONS

BENEFITS

- IN-FLIGHT USE WILL IMPROVE SCIENTIFIC RETURN OF SPACE EXPERIMENTS
  - PROVIDES ON-BOARD SCIENTIFIC EXPERTISE AND ADVICE TO ASTRONAUTS IN REALTIME, THEREBY OPTIMIZING EFFICIENCY OF EXPERIMENT
  - REDUCES CUMBERSOME AIR-TO-GROUND COMMUNICATIONS BETWEEN SCIENTIST AND ASTRONAUTS

APPLICABLE MISSIONS

- SHUTTLE MISSIONS
- SPACE STATION FREEDOM



Astronaut Science Advisor

- Used for ground support of the "Rotating Dome" Experiment aboard Shuttle Mission SLS-1; July, 1991
- Planned for on-board use by crew on Shuttle Mission SLS-2; May, 1993

92-8035

AUTOCLASS IV

NASA — ARC — OAST — RC

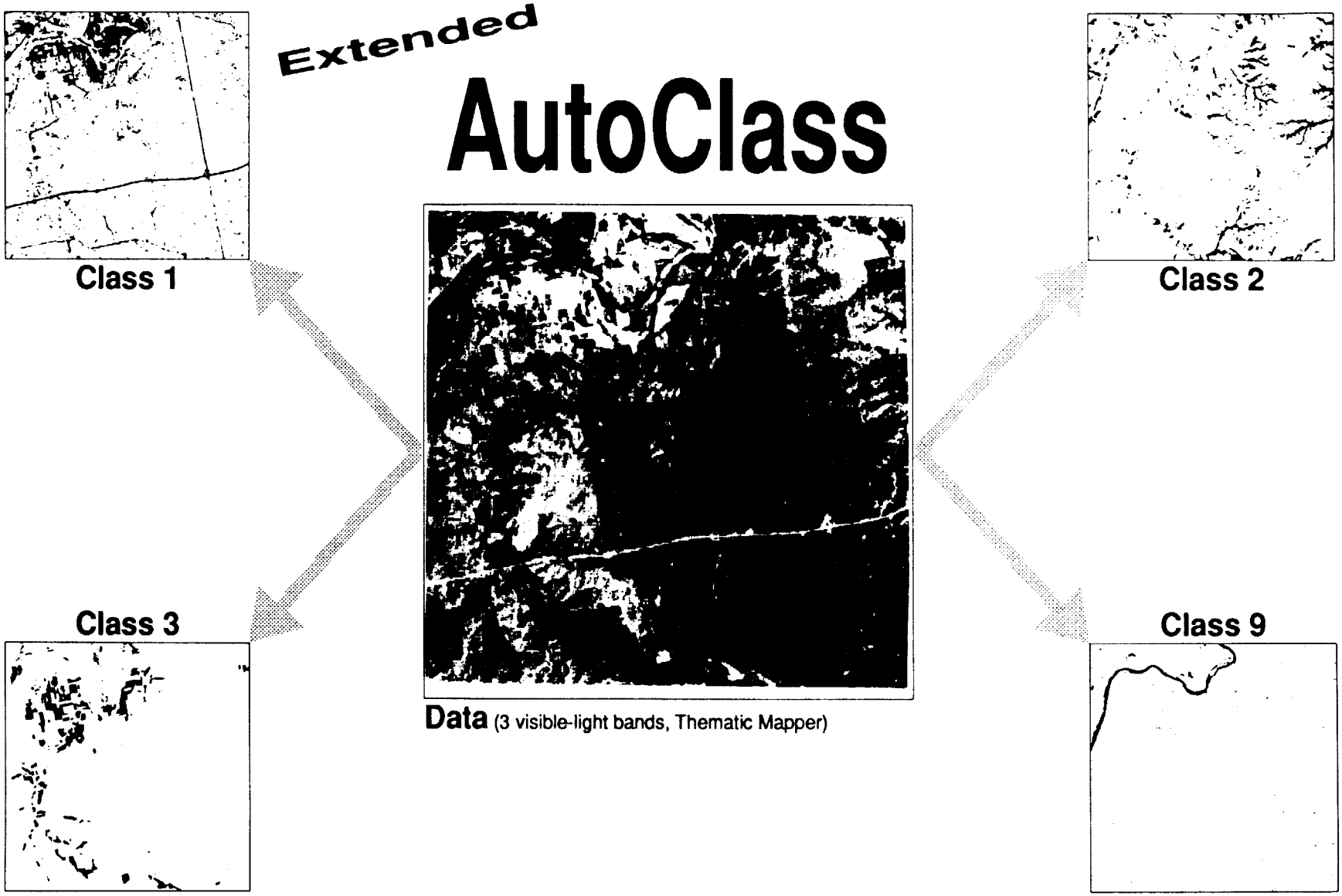
SHOWN
- A 3-BAND LANDSAT IMAGE (CENTER) SURROUNDED BY FOUR OF THE MANY TERRAIN CLASSES DISCOVERED BY AUTOCLASS IV

OBJECTIVE
- DEVELOP AND APPLY AN ARTIFICIAL INTELLIGENCE (AI)-BASED TOOL FOR AUTOMATIC CLASSIFICATION OF VERY LARGE SCIENTIFIC AND ENGINEERING DATABASES

ACCOMPLISHMENT
- COMPLETED DEVELOPMENT OF AUTOCLASS VERSION IV
  - EXPANDED DATA PROCESSING CAPABILITY FROM SIMPLE SPECTRAL DATA (THE IRAS DATABASE) TO MULTI-CHANNEL VISUAL IMAGES (LANDSAT IMAGES)
- APPLIED AUTOCLASS SYSTEM TO CLASSIFICATION OF LANDSAT IMAGES
  - DISCOVERED MANY NEW TYPES OF GROUND COVER THAT WERE PREVIOUSLY UNKNOWN

BENEFITS
- ENABLES PRELIMINARY ANALYSIS OF LARGE, OFTEN NOISY DATABASES
- AUTOMATICALLY FINDS ACTUAL NUMBER OF CLASSES IN THE DATA
- ENABLES IN-SITU, AUTONOMOUS CLASSIFICATION AS WELL AS INTERACTIVE CLASSIFICATION WITH SCIENTISTS

APPLICABLE MISSIONS
- SPACE SCIENCE MISSIONS (e.g. EOS, GREAT OBSERVATORIES)
- SHUTTLE AND SPACE STATION FREEDOM TELEMETRY ANALYSIS



The extended AutoClass implementation was applied to data from Landsat's Thematic Mapper data from a study area (F.I.F.E.) in Kansas, shown in center panel. For each pixel, information from 7 spectral bands was used to build the class descriptions, including the correlations between the bands.

REAL-TIME DATA SYSTEM (RTDS)

NASA — JSC — OAST

RC

SHOWN

- DATA PROCESSING SYSTEM (DPS) DATA MONITORING AND ANALYSIS TOOL (DDMAT) DISPLAY SHOWING CONFIGURATION AND STATUS OF FIVE SHUTTLE ON-BOARD GENERAL PURPOSE COMPUTERS

OBJECTIVE

- TO DEVELOP SHUTTLE MISSION CONTROL APPLICATIONS USING RTDS, AN ARTIFICIAL INTELLIGENCE (AI)-BASED ADVISORY SYSTEM

ACCOMPLISHMENT

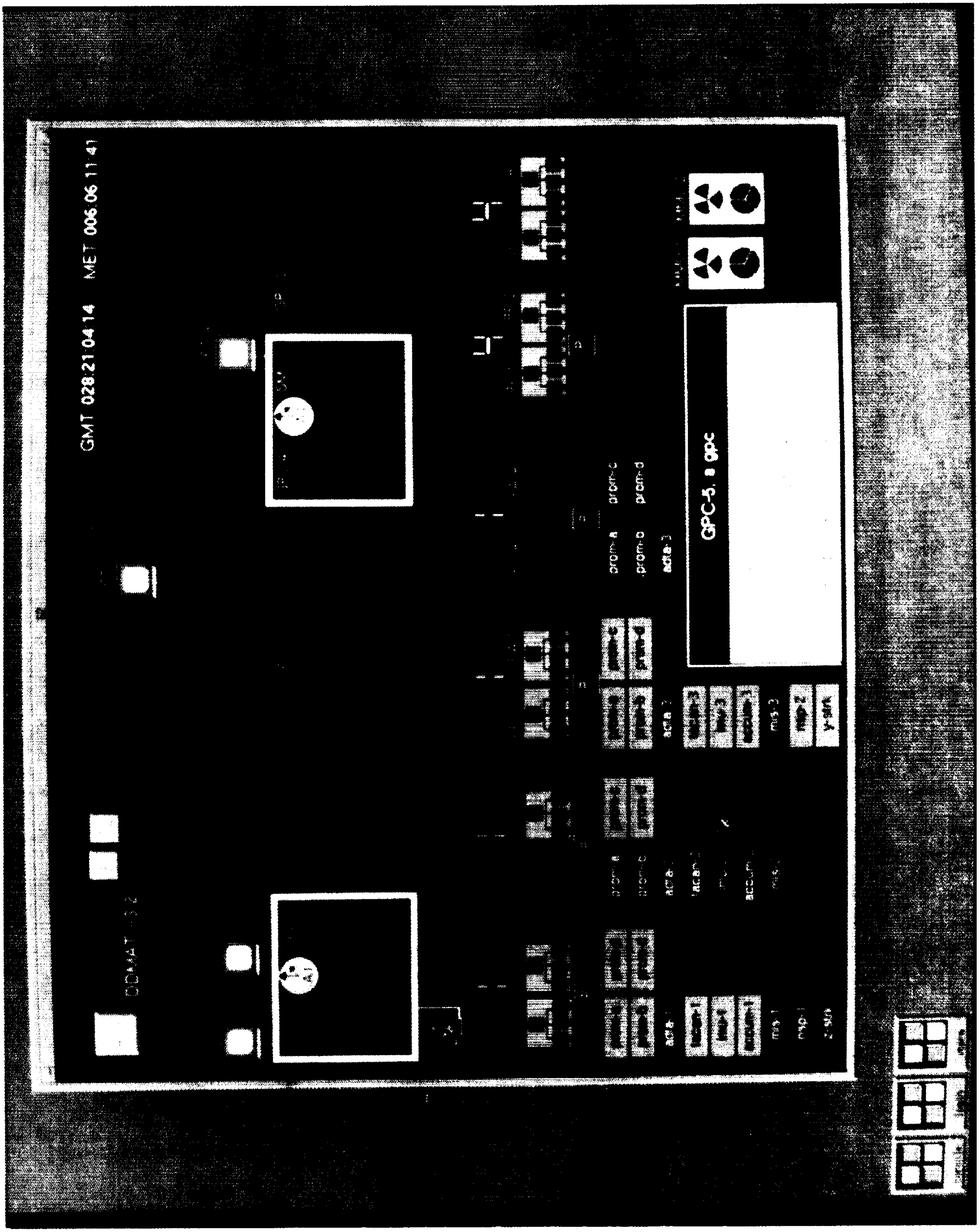
- DEVELOPED A MONITORING AND DISPLAY TOOL (DDMAT) FOR SHUTTLE MISSION CONTROL OPERATIONS

BENEFITS

- PROVIDES EASILY UNDERSTANDABLE GRAPHICS DISPLAY AS COMPARED TO DISPLAY OF 160 INDICATOR LIGHTS AND HEXIDECIMAL PARAMETERS (MOST OF WHICH ARE DISCRETE ON/OFF LIGHTS)
- ENABLES AUTOMATIC DIAGNOSIS OF ON-BOARD FAILURES AS COMPARED TO MANUAL ANALYSIS
- POTENTIAL REDUCTION IN NUMBER OF SHUTTLE MONITORING PERSONNEL
- POTENTIAL REDUCTION IN MISSION CONTROLLER TRAINING TIME

APPLICABLE MISSIONS

- SPACE SHUTTLE



ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

SPACECRAFT HEALTH AUTOMATED REASONING PROTOTYPE (SHARP)

NASA = JPL — OAST

RC

SHOWN
- SHARP COMPUTER DISPLAY SHOWING GALILEO SPACECRAFT ENGINEERING ANALYSIS

OBJECTIVE
- TO DEVELOP REUSABLE AND PORTABLE ARTIFICIAL INTELLIGENCE (AI)-BASED DIAGNOSTIC SYSTEM
- TO APPLY SYSTEM TO SPECIFIC SPACECRAFT MISSIONS

ACCOMPLISHMENT
- COMPLETED REUSABLE, PORTABLE, AI-BASED SYSTEM (SHARP)
- APPLIED SHARP SYSTEM TO SPECIFIC MISSION SUBSYSTEMS
  - MAGELLAN TELECOMMUNICATIONS
  - GALILEO POWER AND PYRO (EMBEDDED WITHIN ENGINEERING ANALYSIS SUBSYSTEM ENVIRONMENT (EASE) MONITORING SYSTEM)

BENEFITS
- DEMONSTRATES MULTI-MISSION, MULTI-SUBSYSTEM APPLICABILITY OF SHARP DIAGNOSTIC SYSTEM AT HIGH LEVEL OF READINESS
- ENHANCED FAULT DETECTION AND ANALYSIS
  - FASTER, MORE ACCURATE DIAGNOSIS OF SYSTEM HEALTH AND ANOMALIES
- SUPPORTS TECHNOLOGY TRANSFER TO FLIGHT PROJECTS, INCLUDING REQUIREMENTS AND DESIGN FOR FUTURE MULTI-MISSION SPACECRAFT ANALYSIS SYSTEM (MSAS)

APPLICABLE MISSIONS
- VOYAGER
- MAGELLAN
- GALILEO
- CRAF/CASSINI
- PLANETARY MISSIONS

SHARP – GALILEO POWER

OAST

POWER AND PYRO SUBSYSTEM
GALILEO MISSION SUPPORT AREA

SHARP/EASE WORKSTATION

SCIENTIFIC ANALYSIS ASSISTANT

NASA — JPL — OAST

RC

SHOWN	● ILLUSTRATION OF MT. PALOMAR SKY SURVEY IMAGE PLATE WITH MACHINE-LEARNING CLASSIFICATION RESULTS
OBJECTIVE	● TO DEVELOP AND DEMONSTRATE ARTIFICIAL INTELLIGENCE (AI) TECHNIQUES TO ASSIST ASTRONOMERS IN AUTOMATED CLASSIFICATION OF ASTRONOMICAL OBJECTS
ACCOMPLISHMENT	● DEVELOPED AI MACHINE-LEARNING ALGORITHMS ● TESTED ALGORITHMS ON SUBSET OF IMAGE DATA FROM MT. PALOMAR - 90.6% ACCURACY IN CLASSIFICATION OF STARS AND GALAXIES
BENEFITS	● ACHIEVES EXPERT HUMAN ASTRONOMER PERFORMANCE ● ENABLES DRAMATICALLY FASTER PRODUCTION OF SCIENTIFIC CATALOG ENTRIES (A FEW DAYS COMPARED TO CURRENT MANUAL METHOD OF 10 YEARS) ● ENABLES HIGHLY AUTOMATED SKY OBJECT CATALOG PRODUCTION
APPLICABLE MISSIONS	● GROUND AND SPACE-BASED ASTRONOMICAL OBSERVATORIES

OPERATIONS FY91

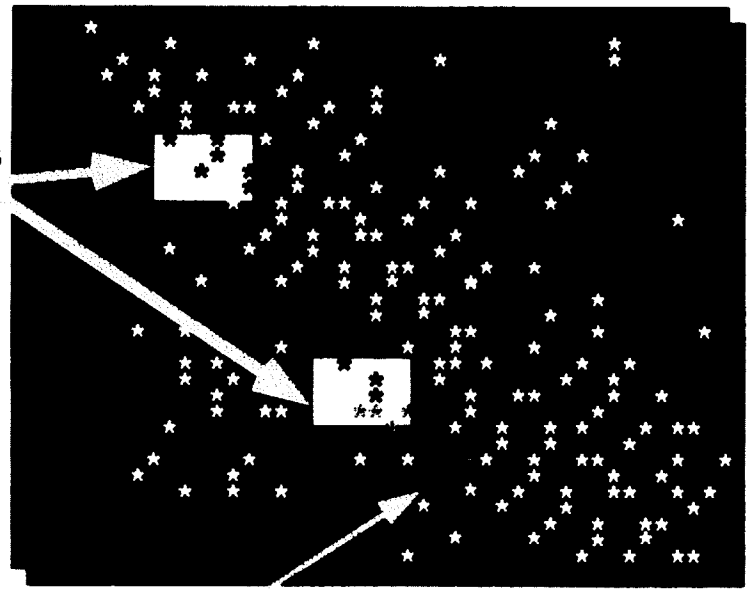
Scientific Analysis Assistant: Sky Object Classification Experiment

JPL

OAST

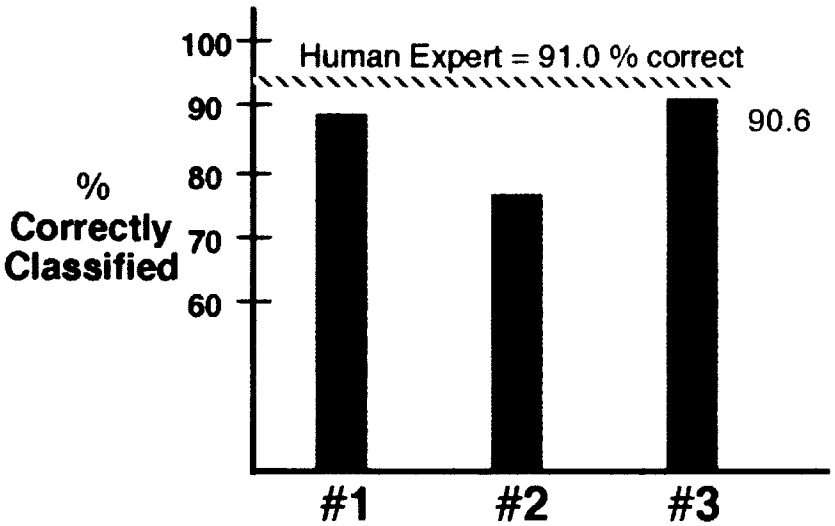
RC

Mt. Palomar Sky Survey Photo Image Plate



Hundreds of thousands of objects (stars, galaxies) in each image to be classified

Machine Learning Test Results



LOSSLESS DATA COMPRESSOR

NASA = GSFC/U. IDAHO — OAST RC

SHOWN
- HIGH PERFORMANCE DATA COMPRESSION CHIP SET

OBJECTIVE
- TO DEVELOP SOURCE ENCODING TECHNIQUES TO MAXIMIZE THE SCIENTIFIC INFORMATION RETURN FROM SPACE PLATFORMS WHICH HAVE CONSTRAINED TELECOMMUNICATION BANDWIDTH
- TO USE HIGH PERFORMANCE VERY LARGE SCALE INTEGRATION (VLSI) TECHNOLOGY TO IMPLEMENT SOURCE ENCODING ALGORITHM

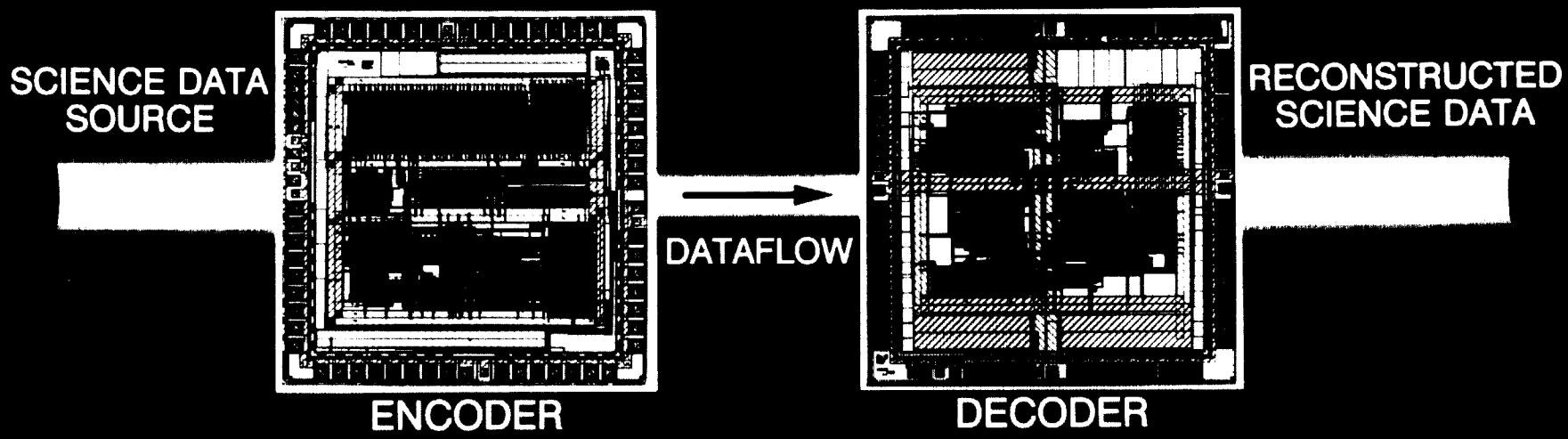
ACCOMPLISHMENT
- DEVELOPED SOURCE ENCODING TECHNIQUES
- DESIGNED, FABRICATED, AND TESTED A LOSSLESS DATA COMPRESSION/ DECOMPRESSION VLSI CHIP SET WITH SOURCE ENCODING ALGORITHM
- FUNCTIONALLY TESTED VLSI CHIP SET AT 700 MBPS DATA RATE

BENEFITS
- 2X INCREASE IN ON-BOARD IMAGING DATA STORAGE CAPACITY
  - ENABLES INCREASE IN SCIENCE DATA RETURN WITHOUT INCREASE IN BANDWIDTH
- 2X REDUCTION IN DATA TRANSMISSION TIME TO GROUND STATION
- SUPPORTS EXTREMELY HIGH DATA RATE INSTRUMENTS (700 MBPS)

APPLICABLE MISSIONS
- EOS
- SSF
- HUBBLE SPACE TELESCOPE
- SUBMILLIMETER WAVE ASTRONOMY SATELLITE
- SDI
- SATURN ORBITER
- COMET RENDEZVOUS ASTEROID FLYBY

OPERATIONS FY91

A VERY HIGH SPEED LOSSLESS DATA COMPRESSION/DECOMPRESSION CHIP SET



ASIC CMOS CHIP DESIGNED BY MICRO-ELECTRONICS RESEARCH CENTER, U. OF IDAHO

USAGE
- INCREASE ONBOARD STORAGE CAPACITY
- INCREASE TELEMETRY TRANSMISSION BANDWIDTH

CHIP SET FEATURES
- ADAPTIVE TO SCENE STATISTICS
- ACCEPTS VARIABLE QUANTIZATION LEVELS: 4-14 BITS/SAMPLE
- ACCEPTS VARIABLE-RATE SCIENCE DATA: MAX AT 20 MSAMPLES/SEC
- REQUIRES <0.4 W POWER

USERS
- HUBBLE SPACE TELESCOPE REV.
- COMET RANDEZVOUS ASTEROID FLY-BY/SATURN ORBITER/ TITAN PROBE
- SMALL EXPLORER/SUB-MILLIMETER WAVE ASTRONOMY SATELLITE
- STRATEGIC DEFENSE INITIATIVE

IMAGING SPECTROMETER FLIGHT PROCESSOR (ISFLIP)

NASA — JPL — OAST

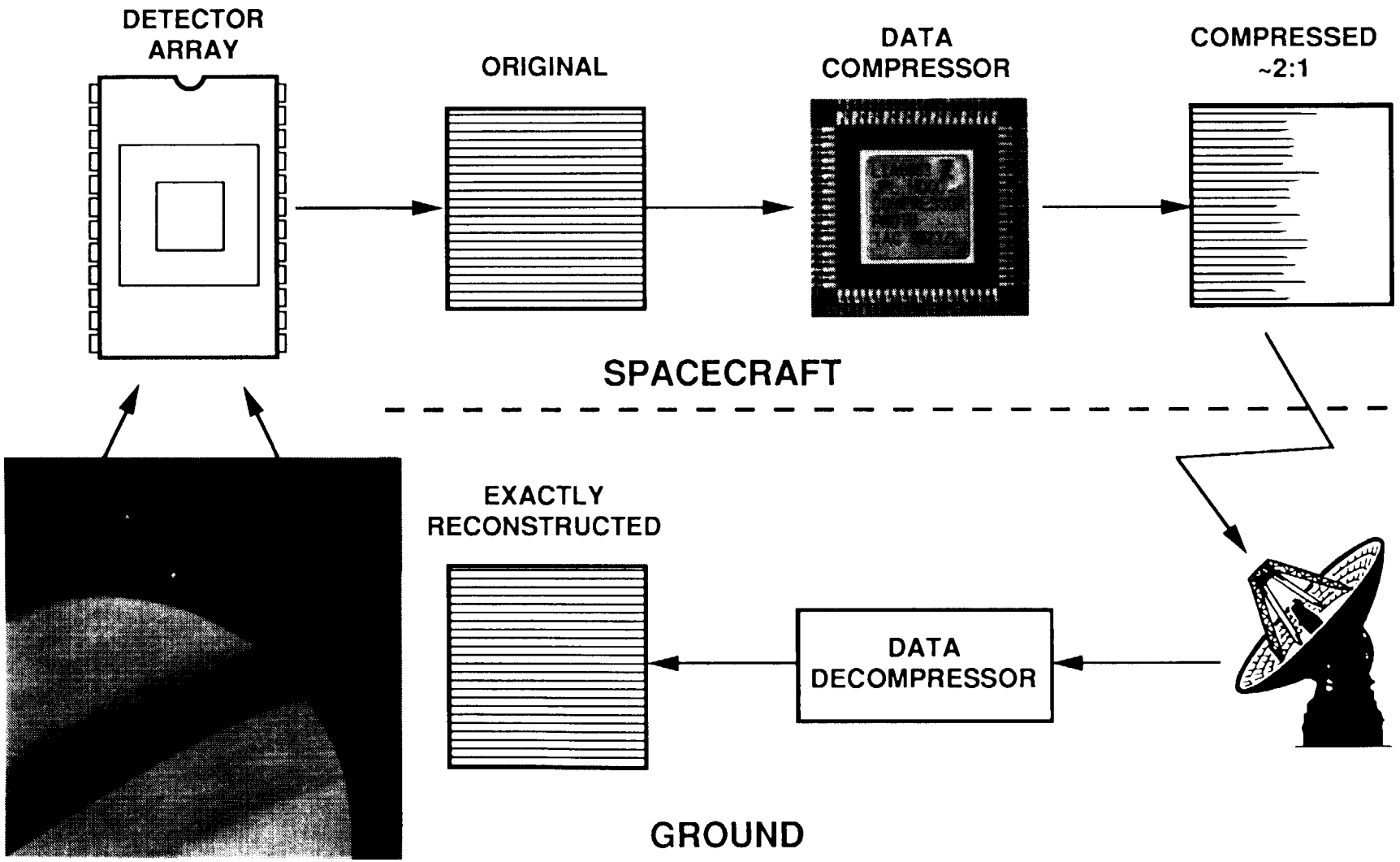
RC

SHOWN	● LOSSLESS DATA COMPRESSION CONCEPT, SHOWING THE PROTOTYPE LOSSLESS DATA COMPRESSOR CHIP DEVELOPED FOR THE EOS HIGH RESOLUTION IMAGING SPECTROMETER (HIRIS) INSTRUMENT
OBJECTIVE	● TO TRANSFER LOSSLESS DATA COMPRESSION TECHNOLOGY FROM A RESEARCH ENVIRONMENT (HIRIS CHIP) TO APPLICATIONS IN FLIGHT PROJECTS BY PERFORMING FEASIBILITY STUDIES FOR POTENTIAL USERS
ACCOMPLISHMENT	● PERFORMED FEASIBILITY STUDY FOR CRAF/CASSINI - EVALUATED DATA SETS FOR CRAF/CASSINI IMAGING SCIENCE SUBSYSTEM ● TRANSFERRED LOSSLESS DATA COMPRESSION TECHNOLOGY TO CRAF/CASSINI IMAGING SCIENCE SUBSYSTEM
BENEFITS	● 2X INCREASE IN ON-BOARD IMAGING DATA STORAGE CAPACITY - ENABLES INCREASE IN SCIENCE DATA RETURN WITHOUT INCREASE IN BANDWIDTH ● 2X REDUCTION IN DATA TRANSMISSION TIME TO GROUND STATION ● SUPPORTS EXTREMELY HIGH DATA RATE INSTRUMENTS
APPLICABLE MISSIONS	● ALL PLANETARY AND EARTH ORBITING MISSIONS

OPERATIONS FY91

JPL

LOSSLESS DATA COMPRESSION/DECOMPRESSION CONCEPT



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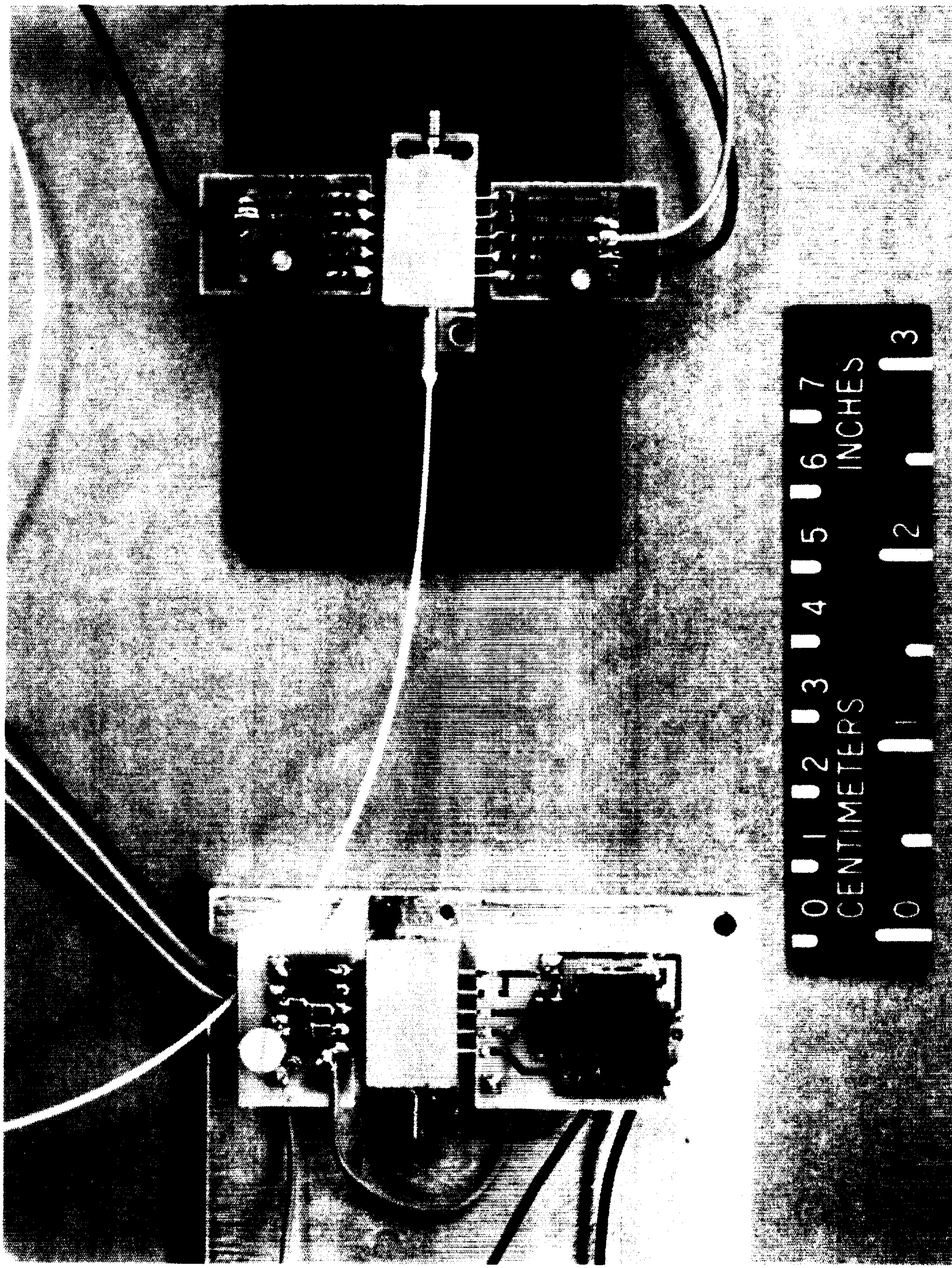
HIGH SPEED FIBER OPTIC TRANSCEIVER

NASA — LaRC — OAST

RC

SHOWN	● 3 GBPS TRANSCEIVER BRASSBOARD IN TEST CONFIGURATION
OBJECTIVE	● TO PROVIDE SPACE-QUALIFIED HIGH-SPEED (3-5 GBPS) FIBER OPTIC TRANSCEIVERS FOR HIGH PERFORMANCE DATA SYSTEM APPLICATION ● TO REDUCE THE OVERALL SIZE AND VOLUME OF THE TRANSCEIVERS WHILE IMPROVING THE OVERALL POWER EFFICIENCY
ACCOMPLISHMENT	● FABRICATED AND TESTED GALLIUM ARSENIDE (GaAs) HYBRID FIBER OPTIC TRANSCEIVER BRASSBOARD TO GREATER THAN 3 GBPS
BENEFITS	● ENABLING TECHNOLOGY FOR WIDE BAND COMMUNICATIONS NETWORKS - ENABLES TRANSMISSION OF DATA AT EXTREMELY HIGH SPEEDS ● 3X REDUCTION IN SIZE OF TRANSMITTER AND RECEIVER ● 30% REDUCTION IN POWER CONSUMPTION
APPLICABLE MISSIONS	● SPACE STATION FREEDOM ● EARTH OBSERVING SYSTEM ● SPACE EXPLORATION INITIATIVE MISSIONS



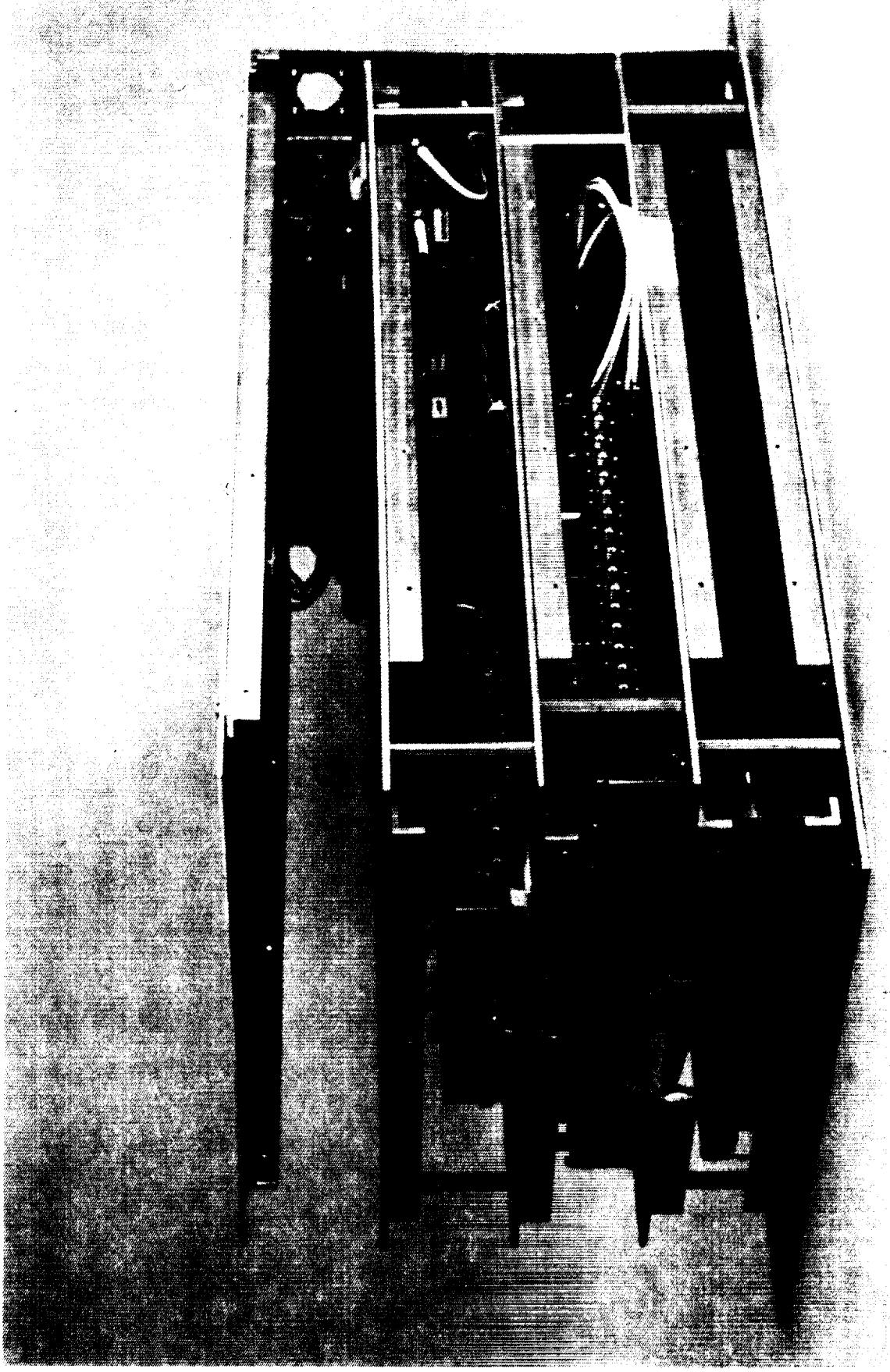
DIGITAL AUTOCORRELATOR SPECTROMETER

NASA — JPL — OAST

RC

SHOWN	● 52-CHANNEL, 125 MHz BANDWIDTH DIGITAL AUTOCORRELATOR SPECTROMETER TO BE FLOWN IN JPL / UNIVERSITY OF CALIFORNIA, SANTA BARBARA (UCSB) BALLOON EXPERIMENT IN JUNE, 1992
OBJECTIVE	● TO DEVELOP HIGH SPEED DIGITAL TECHNOLOGIES FOR WIDEBAND, VERY LOW POWER SPECTROMETERS
ACCOMPLISHMENT	● INTEGRATED 52-CHANNEL DIGITAL AUTOCORRELATOR SPECTROMETER (DEVELOPED IN FY90) INTO JPL/UCSB INSTRUMENT FOR INTERSTELLAR OXYGEN MEASUREMENTS ● CUSTOM-DESIGNED AND FABRICATED 32-CHANNEL CORRELATOR CHIP FOR LOW POWER, HIGHER RESOLUTION APPLICATIONS
BENEFITS	● PROVIDES MORE RELIABLE, MORE STABLE, LOWER POWER, SMALLER SIZE, LOWER MASS TECHNOLOGY COMPARED TO STATE-OF-THE-ART ANALOG SPECTROMETERS ● SPECTROMETERS ENABLE OZONE AND OZONE DEPLETION STUDIES FROM THE MEASUREMENT OF RADIO EMISSION LINES FROM MOLECULES IN THE ATMOSPHERE
APPLICABLE MISSIONS	● BALLOON MICROWAVE LIMBSOUNDER SYSTEM (BMLS) ● EOS MICROWAVE LIMBSOUNDER (MLS) ● LARGE DEPLOYABLE REFLECTOR

OPERATIONS FY91



SPACEFLIGHT OPTICAL DISK RECORDER (SODR)

NASA — LaRC — OAST

RC

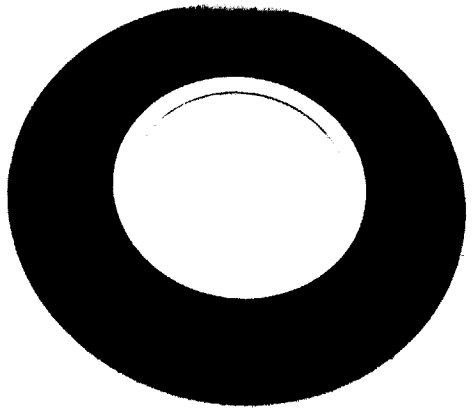
SHOWN	● 9-ELEMENT LASER DIODE ARRAY AND GLASS MEDIA COMPONENTS OF SODR; SOFTWARE MODEL OF EXPANDABLE ARCHITECTURE; BREADBOARD TESTING OF SYSTEM CONTROLLER
OBJECTIVE	● TO DEVELOP COMPONENTS AND SUBSYSTEMS FOR HIGH-PERFORMANCE REWRITEABLE OPTICAL DISK RECORDERS
ACCOMPLISHMENT	● DEVELOPED 300 MBPS DIODE ARRAY AND GLASS MEDIA FOR INSERTION INTO SODR
BENEFITS	● ENABLING TECHNOLOGY FOR LARGE SCALE MASS MEMORY SYSTEMS - RECORDS FASTER (300 MBPS PER DISK, UP TO 1200 MBPS FOR MULTI-DISK SYSTEM) - RECORDS MORE (10 GBYTES PER DISK, UP TO 160 GBYTES FOR MULTI-DISK SYSTEM) - MORE RELIABLE STORAGE TECHNOLOGY (NO MEDIA OR HEAD WEAR) - EXPANDABLE, RECONFIGURABLE SYSTEM ARCHITECTURE (UP TO 16 DISKS)
APPLICABLE MISSIONS	● SPACE STATION FREEDOM ● EARTH OBSERVING SYSTEM ● PLANETARY ROVERS AND LANDERS ● LEO / GEO MISSIONS ● SPACE EXPLORATION INITIATIVE MISSIONS

OPERATIONS FY91

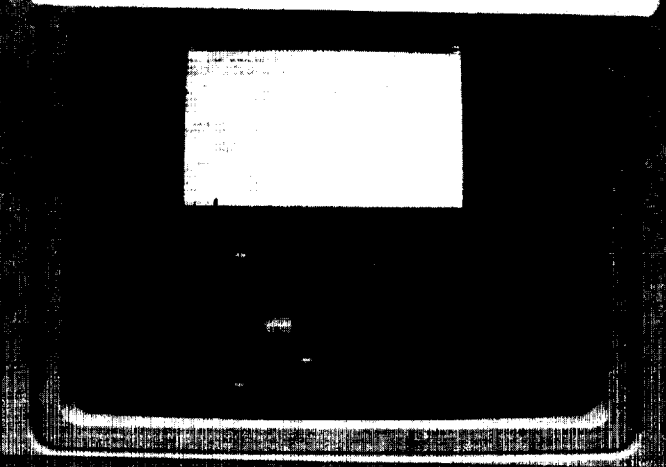
SPACEFLIGHT OPTICAL DISK RECORDER

FY '91 ACCOMPLISHMENTS

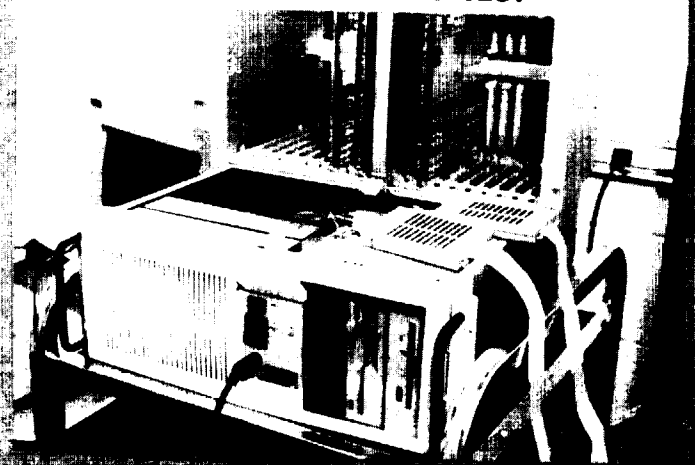
DEVELOPMENTAL GLASS MEDIA



SINGLE DRIVE SYSTEM MODEL



BREADBOARD CONTROLLER FABRICATION & TEST



DEVELOPMENTAL LASER ARRAY TESTING

INTELLIGENT DATA MANAGEMENT

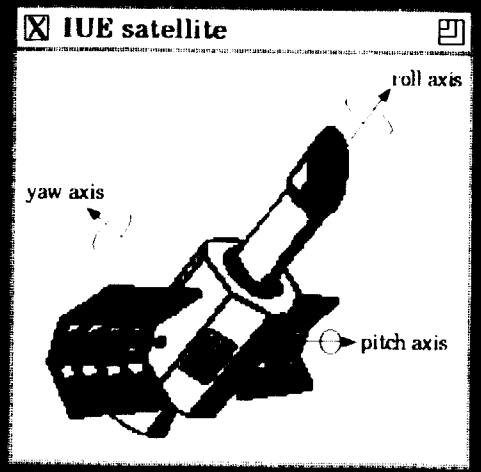
NASA — GSFC — OAST — RC

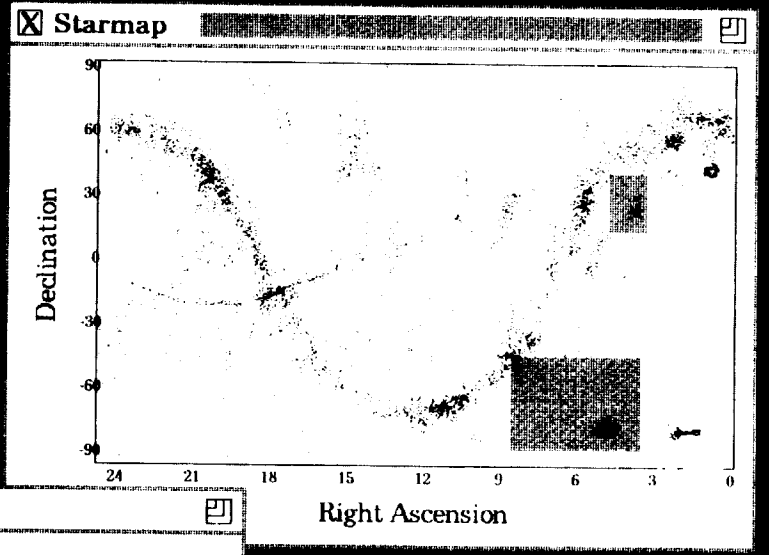
SHOWN	● INTELLIGENT USER INTERFACE TO THE INTERNATIONAL ULTRAVIOLET EXPLORER (IUE) DATA CATALOG
OBJECTIVE	● TO DEVELOP INTELLIGENT USER INTERFACES TO SCIENTIFIC DATABASES SO THAT SCIENTISTS CAN EASILY FIND AND RETRIEVE THE INFORMATION PERTINENT TO THEIR RESEARCH
ACCOMPLISHMENT	● DEVELOPED INTELLIGENT USER INTERFACE TO THE IUE DATA CATALOG
BENEFITS	● ENABLES SCIENTISTS TO QUERY DATABASE USING ENGLISH AND GRAPHICS (COMPARED TO STRUCTURING QUERIES IN THE FORM OF A SPECIALIZED DATABASE QUERY LANGUAGE) ● ENABLES EASIER, FASTER ACCESS TO DATA (IN SECONDS, COMPARED TO MINUTES OR HOURS) - SAVES SCIENTISTS' TIME WHICH CAN BE BETTER UTILIZED IN ANALYSIS - DECREASES COMPUTING POWER REQUIREMENTS
APPLICABLE MISSIONS	● SPACE-BASED SCIENTIFIC MISSIONS

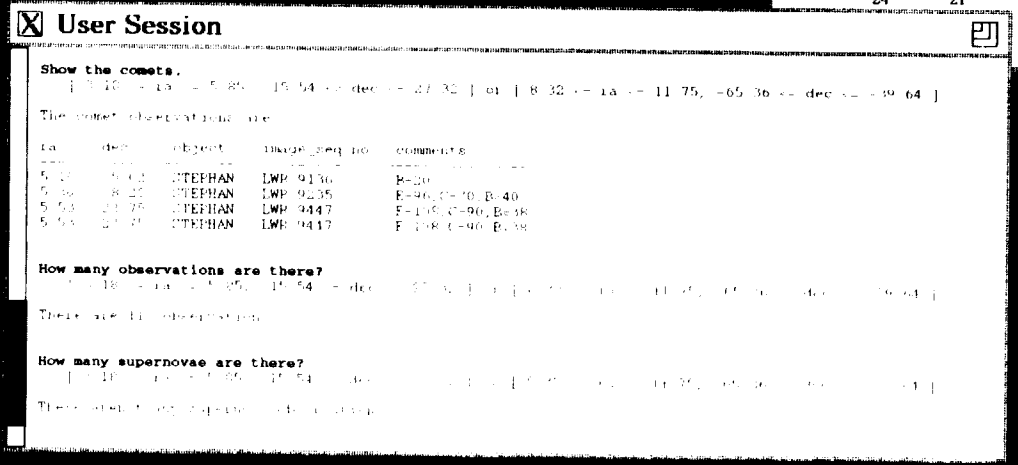
IDM

Intelligent Data Management

International Ultraviolet Explorer Catalog Query System







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ORIGINAL PAGE
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ADVANCED DIGITAL SAR PROCESSOR (ADSP)

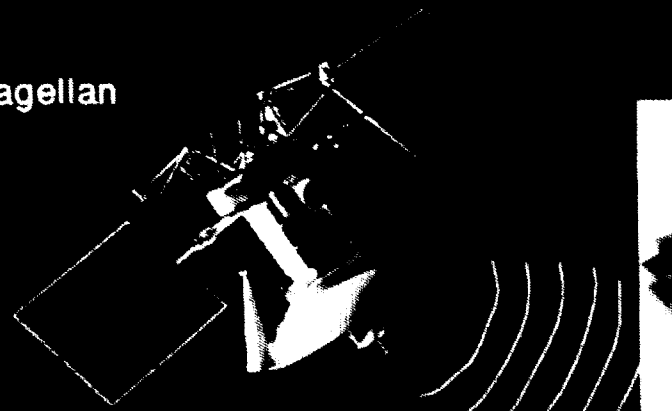
NASA = JPL — OAST

RC

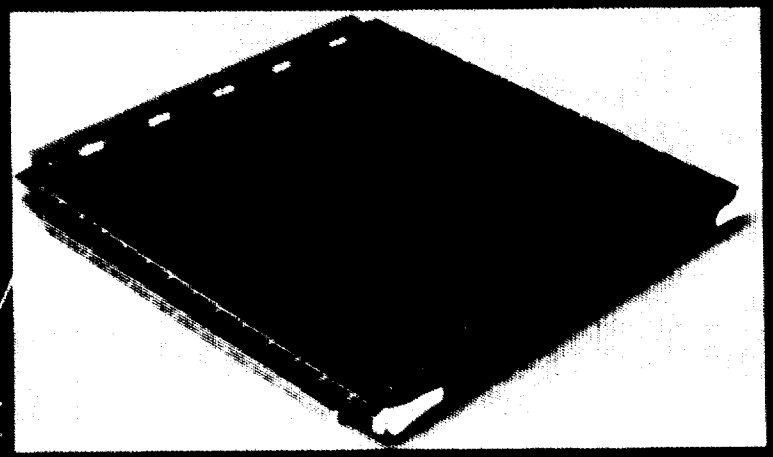
SHOWN	● SURFACE IMAGE OF VENUS PROCESSED THROUGH THE ADSP-BASED SAR DATA PROCESSING SYSTEM ON MAGELLAN
OBJECTIVE	● TO DEVELOP COMPUTING TECHNOLOGY TO ENABLE SYNTHETIC APERTURE RADAR (SAR) DATA PROCESSING AT A REAL-TIME RATE
ACCOMPLISHMENT	● DEVELOPED ADSP WHICH ENABLES SAR DATA PROCESSING FASTER THAN REAL-TIME ● ADSP ADOPTED BY MAGELLAN PROJECT AS PRIMARY MISSION OPERATIONS SAR DATA PROCESSOR
BENEFITS	● $10M ESTIMATED SAVINGS OVER DEVELOPING CONVENTIONAL COMPUTING HARDWARE SYSTEM TO PERFORM SAR DATA PROCESSING ● ENABLES HIGH SPEED DATA PROCESSING FOR VOLUMINOUS DATA - ORDER OF MAGNITUDE FASTER DATA PROCESSING COMPARED TO CURRENT SAR DATA PROCESSING SYSTEMS ● SAR PROCESSING ENABLES REMOTE SENSING CONTINUOUS OPERATION REGARDLESS OF LIGHT (DAY/NIGHT) OR CLOUD COVERAGE (CLEAR/CLOUDY)
APPLICABLE MISSIONS	● SAR INSTRUMENT MISSIONS (MAGELLAN, SEASAT, SIR-A, SIR-B, SIR-C)

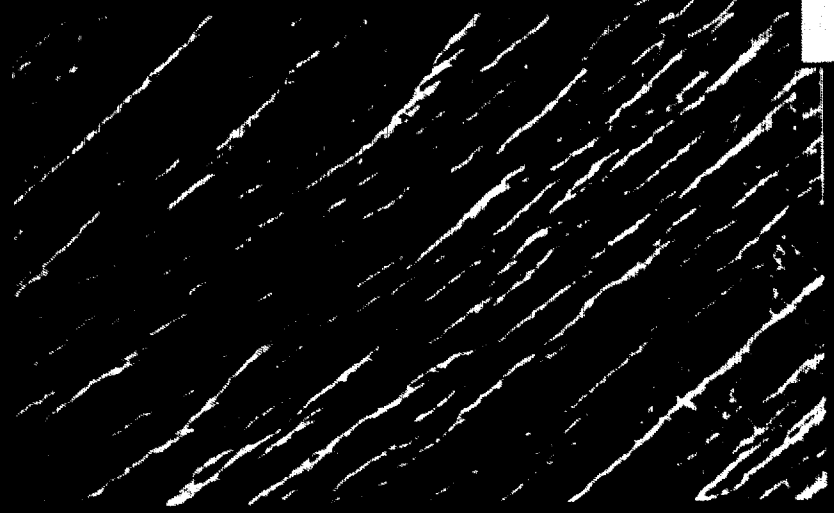
SYNTHETIC APERTURE RADAR PROCESSOR

Magellan



SAR Processor





Venus Surface Characteristics

Venus

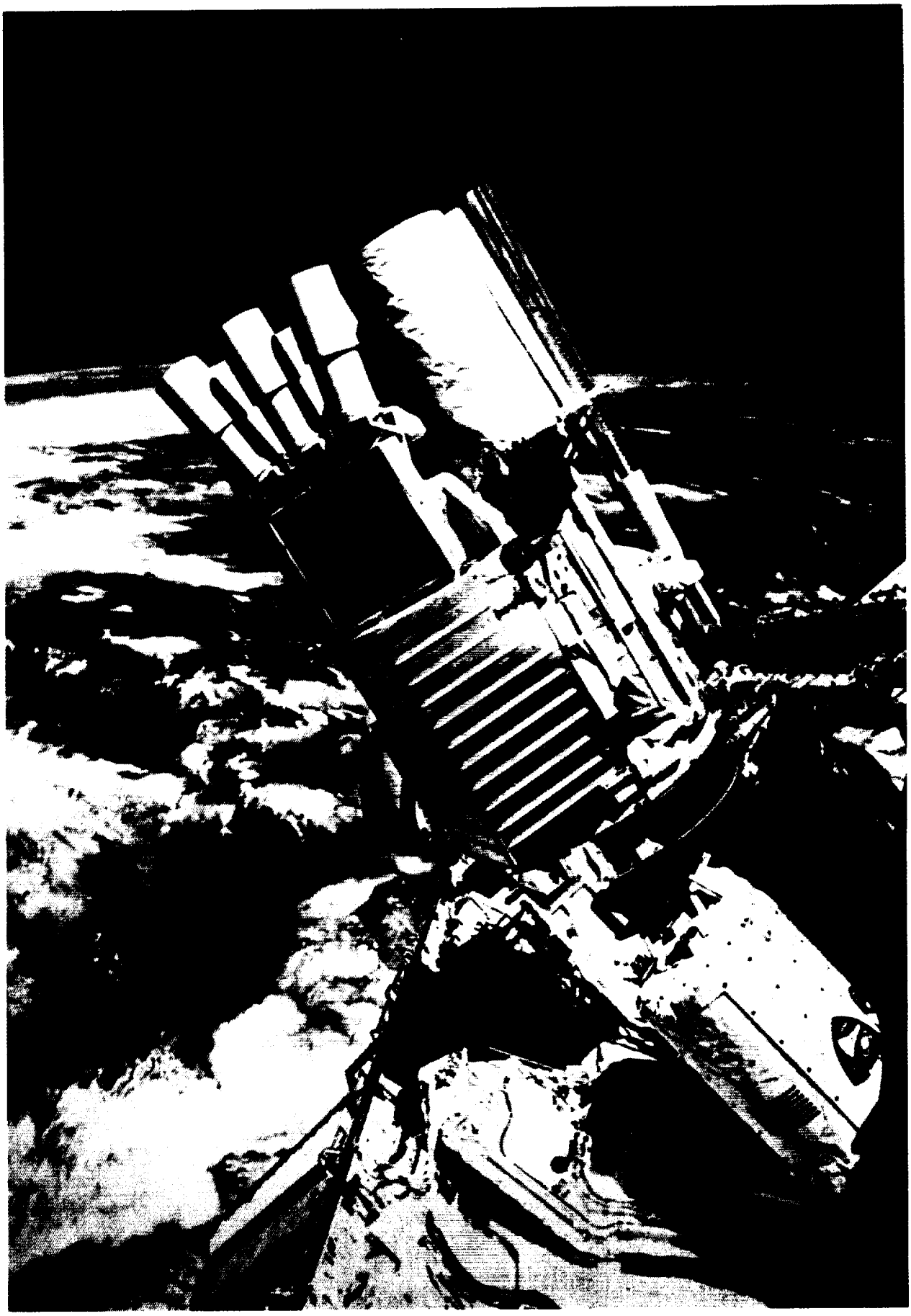
Office of Aeronautics, Exploration and Technology

ASTRO STAR TRACKER

NASA — JPL — OAST

RC

SHOWN	● ASTRO-1 SHUTTLE MISSION USING STAR TRACKER
OBJECTIVE	● TO DEMONSTRATE CODE R-DEVELOPED (1975-1982) SOLID-STATE STAR TRACKER TECHNOLOGY BASED ON CHARGE COUPLED DEVICES (CCDs)
ACCOMPLISHMENT	● DEMONSTRATED SOLID-STATE STAR TRACKER ON SHUTTLE ASTRO-1 MISSION IN DECEMBER 1990 - TRACKER ACQUIRED GUIDE STARS FOR ALL 140+ SCIENCE TARGETS
BENEFITS	● CCD TECHNOLOGY MORE RELIABLE (ENABLES STAR ACQUISITION AND TRACKING ANYWHERE IN THE SKY) COMPARED TO IMAGE DISSECTOR TECHNOLOGY (TRACKERS FREQUENTLY FAIL IN ACQUISITION, ESPECIALLY WHEN ONLY FAINT STARTS ARE AVAILABLE) ● CRUCIAL ELEMENT IN SUCCESSFUL OUTCOME OF ASTRO-1 MISSION (ALL 3 PRIMARY TRACKERS FAILED TO ACQUIRE PROPER TARGETS)
APPLICABLE MISSIONS	● MISSIONS REQUIRING HIGH ANGULAR ACCURACY OR FIELD IDENTIFICATION ● MISSIONS REQUIRING TRACKING AND SCANNING

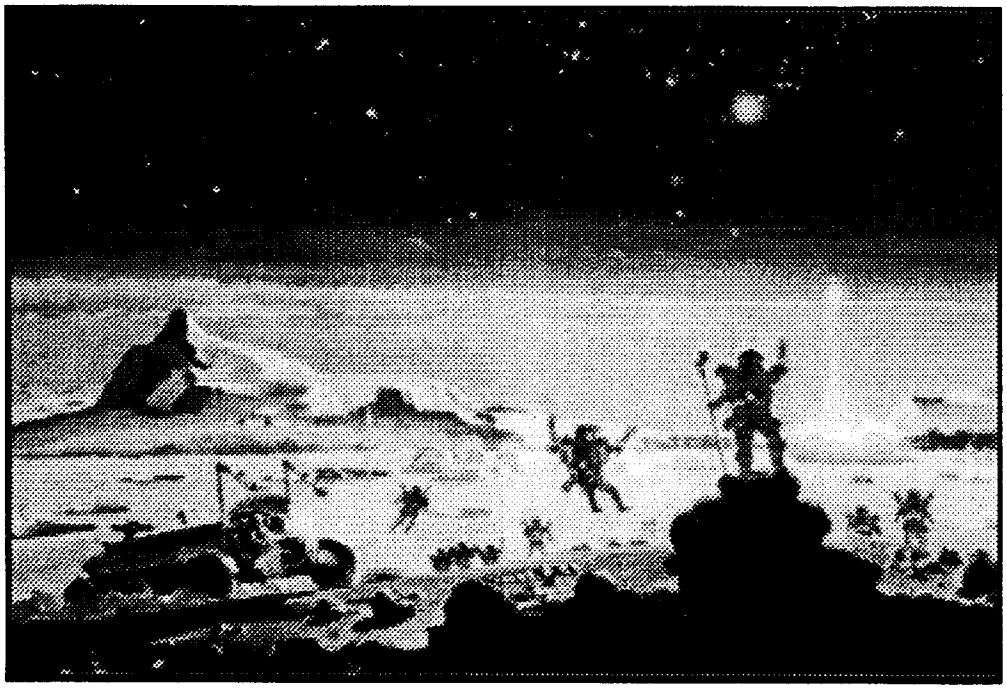


PLANETARY SURFACE

FOCUSSED PROGRAM

PLANETARY SURFACE TECHNOLOGY

PROVIDE KEY TECHNOLOGIES FOR ROBOTIC AND MANNED PLANETARY SURFACE EXPLORATION SYSTEMS INCLUDING CAPABILITIES FOR AN OUTPOST ON THE MOON AND EXPLORATION OF THE PLANET MARS



- INCREASE RELIABILITY AND REDUCE RISK; REDUCE DEVELOPMENT AND OPERATIONS COST; AND ENABLE NEW AND INNOVATIVE CAPABILITIES IN THE AREAS OF:
  - ADVANCED SURFACE SYSTEM OPERATIONS ON THE MOON AND MARS
  - TECHNOLOGIES FOR HUMAN SUPPORT DURING VERY LONG DURATION PILOTED MISSIONS IN DEEP-SPACE AND ON PLANETARY SURFACES

AUTONOMOUS MOBILE EXPLORATION ROBOT

NASA — JPL/CMU — OAST

RC

SHOWN

- AUTONOMOUS MOBILE EXPLORATION ROBOT (AMPLER) IN PLANETARY ROBOTICS TEST FACILITY AT CARNEGIE-MELLON UNIVERSITY

OBJECTIVE

- TO DEVELOP A HIGHLY CAPABLE MOBILE ROBOT TESTBED
- TO EVALUATE THE APPLICABILITY OF INNOVATIVE ROBOTIC MORPHOLOGIES (DESIGN APPROACHES) TO PLANETARY SURFACE EXPLORATION IN EXTREME ENVIRONMENTS

ACCOMPLISHMENT

- DEVELOPED THE AMBLER ROBOTIC VEHICLE WITH ASSOCIATED PERCEPTION AND CONTROL SYSTEMS
- DEPLOYED AND EVALUATED AMBLER VIA EXTERNAL AND NOCTURNAL EXPLORATION SORTIES
- DEVELOPED THREE SIGNIFICANT NEW ROBOTIC TECHNOLOGIES
  - DECOUPLED LEG JOINT DESIGN FOR STABLE MACHINE WALKING
  - ACTIVE RANGE SENSING FOR TERRAIN MAP CONSTRUCTION
  - TASK CONTROL ARCHITECTURE (TCA) FOR COORDINATION OF ROBOTIC COMPUTATION TASKS

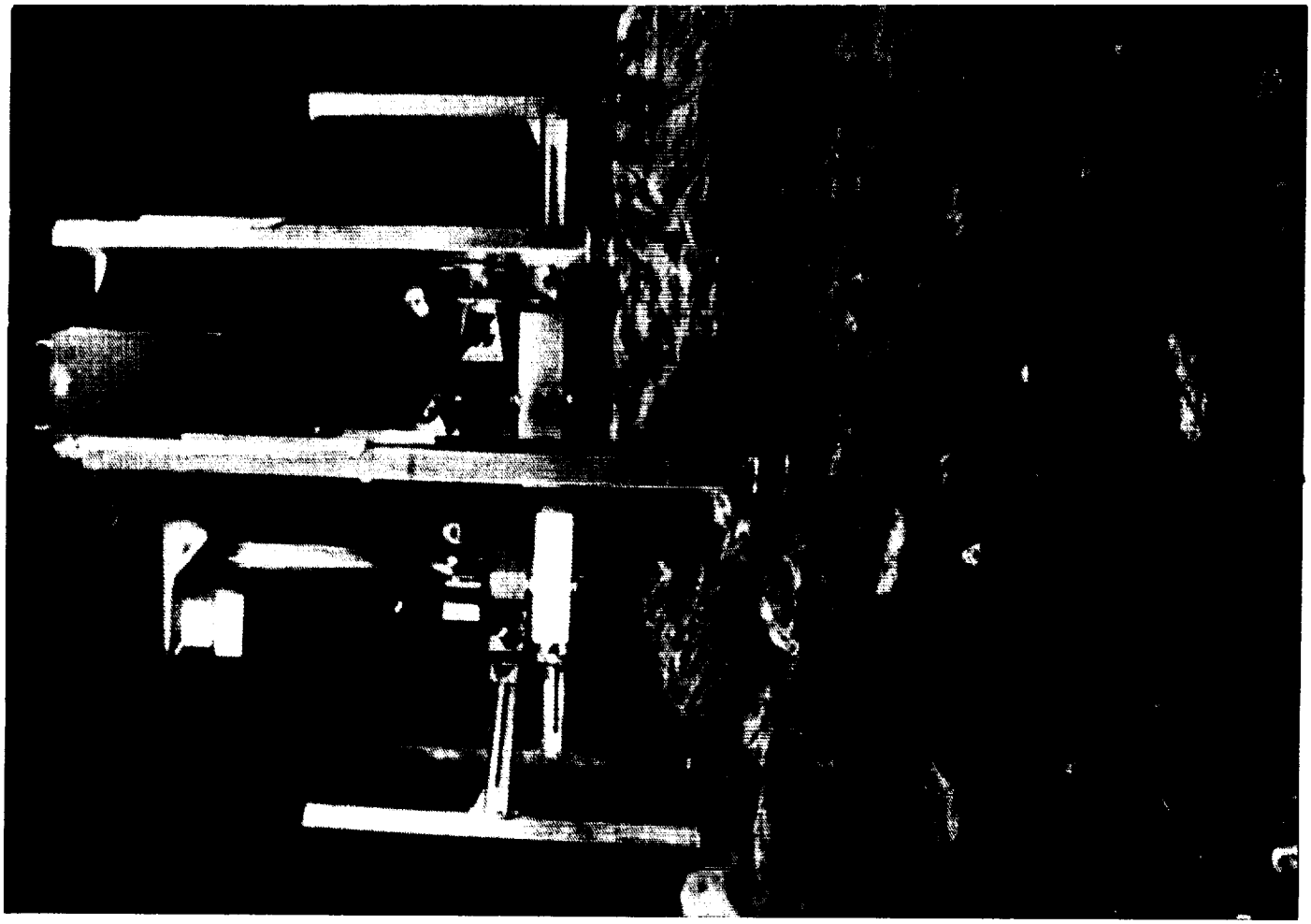
BENEFITS

- LEGGED DESIGNS OFFER GREATER MOBILITY THAN COMPARABLY SIZED WHEELED VEHICLES, PERMITTING EXPLORATION OF A GREATER VARIETY OF EXTREME TERRAINS
- LEGGED VEHICLES ARE HIGHLY EFFICIENT IN TERMS OF POWER UTILIZATION, REQUIRING SMALLER/LIGHTER POWER SYSTEMS
- CONTINUOUSLY LEVEL BODY MOTION OFFERS A STABLE PLATFORM FOR SAMPLING AND SCIENCE PAYLOADS

APPLICABLE MISSIONS

- MARS ENVIRONMENTAL SURVEY (MESUR)
- MARS EXPLORATION
- SCIENCE INSTRUMENT DEPLOYMENT

OPERATIONS FY91

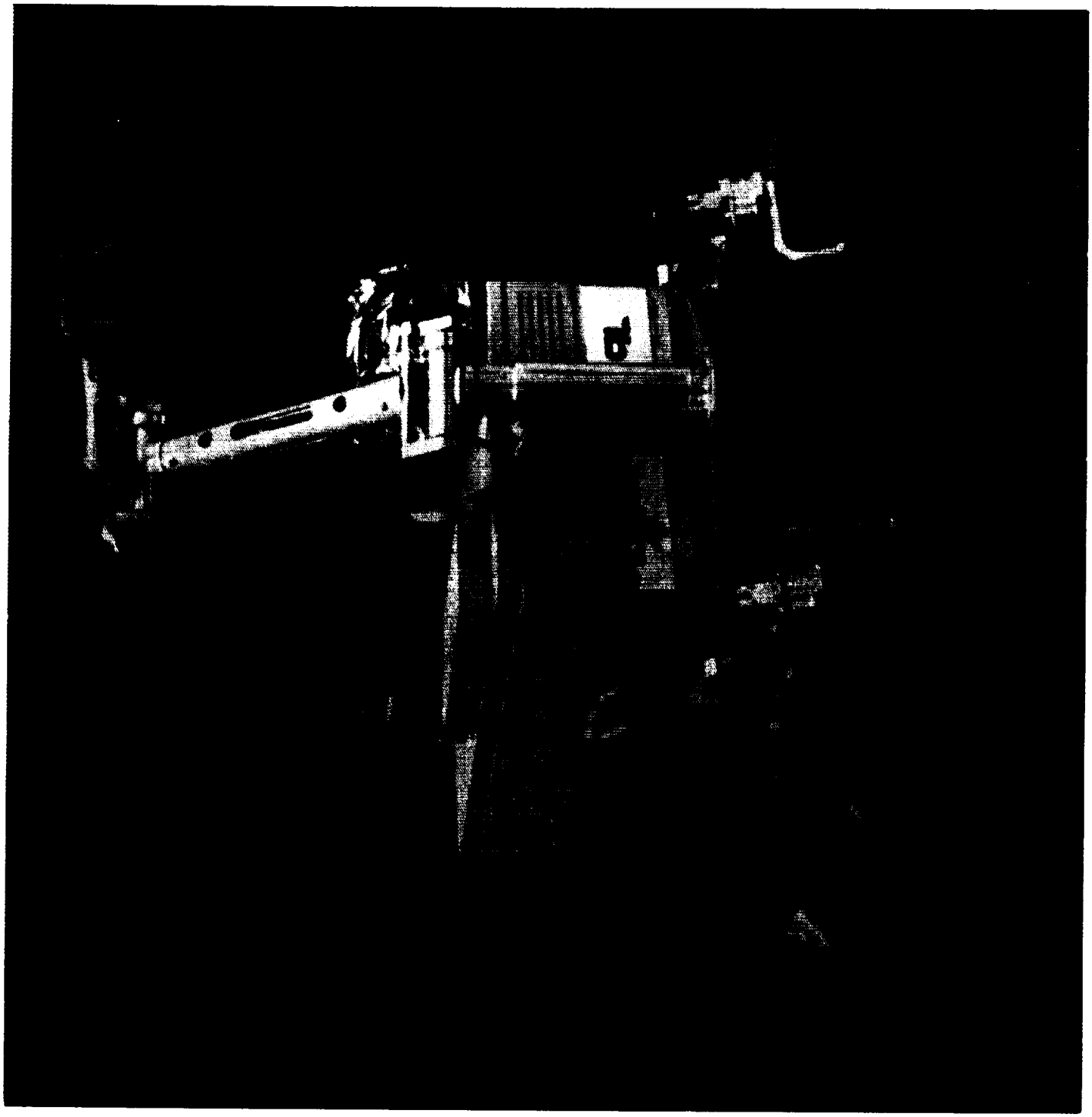


MINI-ROVER TECHNOLOGY

NASA — JPL — OAST

RC

SHOWN	● "ROCKY III" MINI-ROVER TEST VEHICLE DEVELOPED BY JPL INTELLIGENT ROBOTICS LABORATORY
OBJECTIVE	● TO DEVELOP AND DEMONSTRATE A SMALL MOBILE ROVER TO EVALUATE LESS COMPLEX, LESS COSTLY ROVERS FOR PLANETARY EXPLORATION
ACCOMPLISHMENT	● DEVELOPED 20-KILOGRAM CLASS MINI-ROVER WHICH UTILIZES SIMPLE SENSING SYSTEMS AND BEHAVIOR CONTROL ARCHITECTURES TO PERFORM SIMULATED SAMPLE ACQUISITION TASKS ● DEMONSTRATED ROVER SAMPLE ACQUISITION TASK IN JPL ARROYO TEST SITE - AUTONOMOUSLY TRAVERSED 20 METERS FROM THE SIMULATED LANDER SITE TO A DESIGNATED SAMPLE COLLECTION LOCATION - SENSED AND AVOIDED OBSTACLES HAZARDOUS TO THE VEHICLE DURING THE TRAVERSE - IDENTIFIED AND ACQUIRED COLLECTIBLE SAMPLES - RETURNED TO SIMULATED LANDER AND DEPOSITED SAMPLES
BENEFITS	● REDUCED SIZE OF VEHICLE PERMITS GREATER SCIENCE/EXPLORATION PAYLOAD CAPABILITY ● REDUCED COMPLEXITY OF VEHICLE LEADS TO INCREASED ROBUSTNESS, AND HOLDS POTENTIAL FOR REDUCED COST OF OPERATIONAL ROVER SYSTEMS
APPLICABLE MISSIONS	● MARS ENVIRONMENTAL SURVEY (MESUR) ● MARS EXPLORATION ● SCIENCE INSTRUMENT DEPLOYMENT



STIRLING COLD END MOTORING TEST

NASA — LeRC — OAST

RP

SHOWN

- COLD END OF 12.5 kWe/PISTON 1050K STIRLING POWER CONVERTER

OBJECTIVE

- DEVELOP AND DEMONSTRATE A 25% EFFICIENT 12.5 kWe/PISTON 1050K STIRLING POWER CONVERTER WITH COLD END TEMPERATURE OF 525K FOR USE WITH NUCLEAR SPACE POWER SYSTEMS RANGING FROM 25-800 kWe

ACCOMPLISHMENT

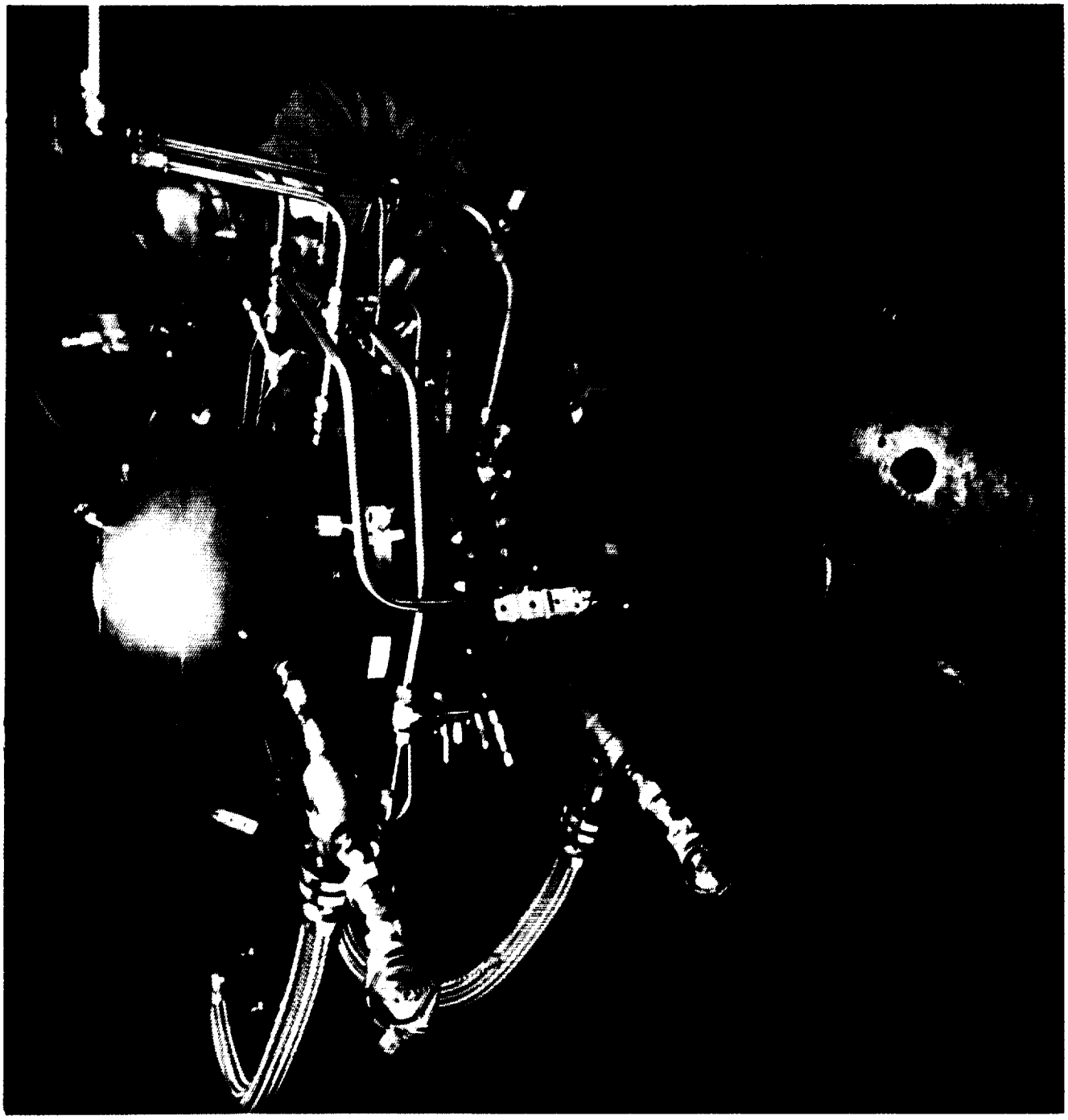
- DEVELOPED COLD END PORTION OF THE STIRLING POWER CONVERTER, AND COMPLETED MOTORING TESTS AT A COLD END TEMPERATURE OF 525K
- FIRST TIME DEMONSTRATION OF LOW-POWER-LOSS, SELF-PUMPED, ZERO-WEAR HYDROSTATIC GAS BEARINGS WHICH FUNCTION OVER THE ENTIRE POWER OPERATING RANGE

BENEFITS

- MOTORING TEST VERIFIED DESIGN OF HIGH TEMPERATURE (525K) COMPONENT PARTS (ALTERNATOR, GAS BEARINGS, AND CLEARANCE SEALS)
- INCREASE IN COLD END OPERATING TEMPERATURE FROM 300K TO 525K ENABLES REDUCED SIZE / REDUCED MASS OF RADIATOR AND THEREFORE REDUCED LAUNCH COSTS WITH INCREASED PAYLOAD POTENTIAL
- STIRLING POWER CONVERSION SYSTEM OFFERS 6X INCREASE IN SYSTEM EFFICIENCY COMPARED TO SP-100 THERMOELECTRICS

APPLICABLE MISSIONS

- LUNAR SURFACE POWER AND ROVER POWER
- MARTIAN SURFACE POWER AND ROVER POWER
- DYNAMIC ISOTOPE POWER SYSTEMS FOR SPACE SCIENCE



SP-100 THERMOELECTRIC MULTICELL

NASA = JPL/DOE/GE — OAST

RP

SHOWN

- SP-100 THERMOELECTRIC MULTICELL

OBJECTIVE

- TO DEVELOP A 10-YEAR LIFE, RELIABLE THERMOELECTRIC MULTICELL THAT CAN PRODUCE 13 WATTS (30% IMPROVEMENT IN POWER OUTPUT) AT OPERATING TEMPERATURES OF 1305K (HOT SIDE) AND 863K (COLD SIDE)

ACCOMPLISHMENT

- DEVELOPED ELECTRICAL INSULATOR AND COMPLIANT PAD COMPONENTS OF SP-100 THERMOELECTRIC MULTICELL
- TESTED INSULATOR AND COMPLIANT PAD AT PROTOTYPIC OPERATING CONDITIONS IN AN OPERATING MULTICELL
  - ACHIEVED PREDICTED MULTICELL POWER OUTPUT OF 8.7 WATTS WITH INSULATOR AND COMPLIANT PAD WHILE OPERATING AT TEMPERATURES OF 1300K (HOT SIDE) AND 900K (COLD SIDE)
- COMPLETED AND EXPERIMENTALLY VERIFIED MULTICELL STRESS AND FRACTURE MODELS
- ACHIEVED 15% IMPROVEMENT IN THERMOELECTRIC MATERIAL POWER OUTPUT

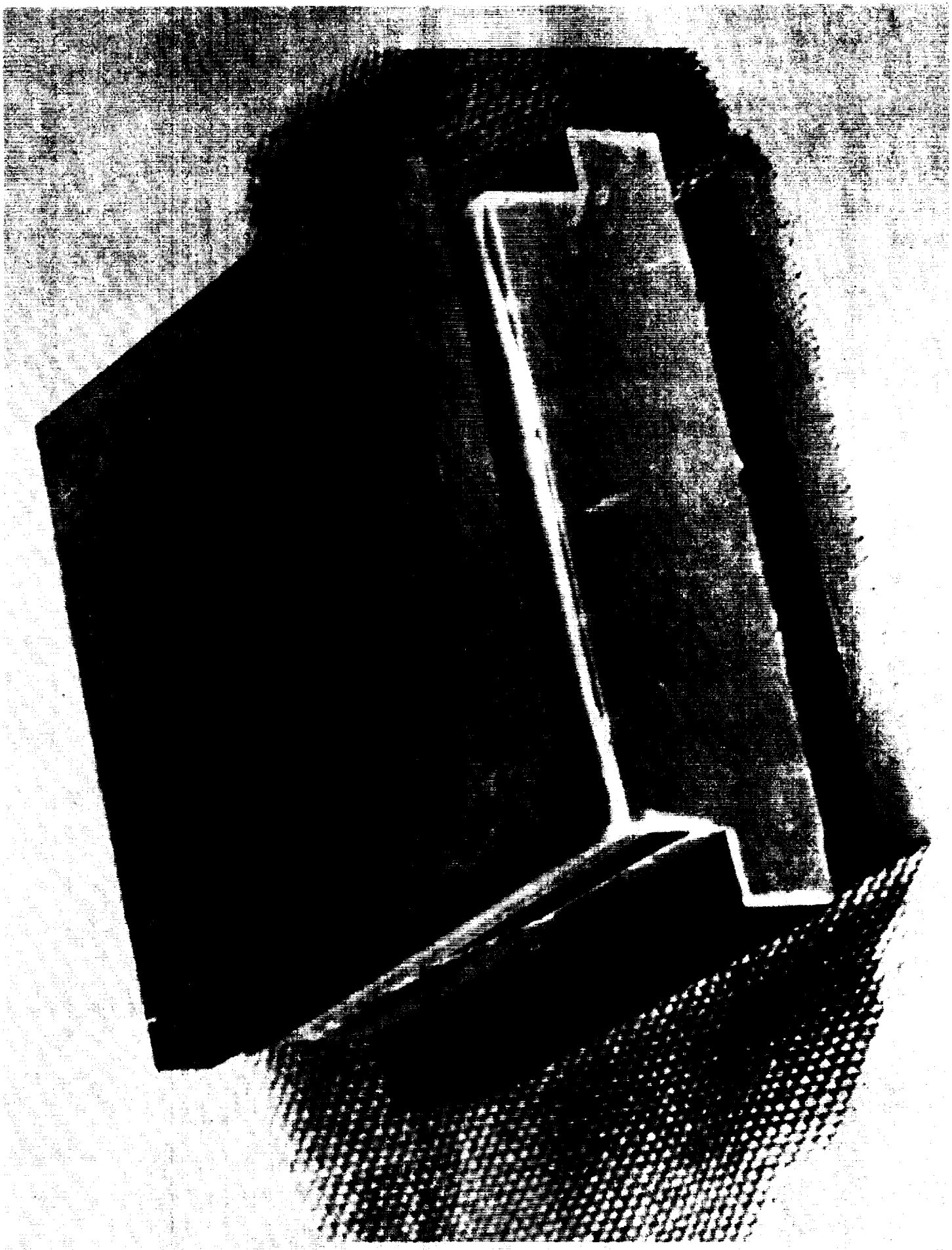
BENEFITS

- VALIDATES SP-100 THERMOELECTRIC CONDUCTIVELY COUPLED MULTICELL WHICH IS NEEDED TO MEET APPLICABLE MISSION REQUIREMENTS
- ACHIEVES MORE OUTPUT POWER IN SAME VOLUME
  - 16X INCREASE IN POWER OF THERMOELECTRIC MULTICELL AS COMPARED WITH STATE-OF-THE-ART RADIOISOTOPE THERMOELECTRIC GENERATOR (RTG) UNICOUPLES

APPLICABLE MISSIONS

- ROBOTIC PLANETARY SCIENCE MISSIONS
- LUNAR AND MARS BASE

PLANETARY SURFACE FY91



REGENERATIVE LIFE SUPPORT

NASA — JPL — OAST

RP

SHOWN
- RESULTS OF CARBON DIOXIDE REMOVAL TECHNOLOGY TRADES FOR LUNAR HABITAT SHOWING THE IMPACT OF ALTERNATE TECHNOLOGIES ON THE AIR REVITALIZATION SUBSYSTEM & ON THE ENTIRE LIFE SUPPORT SYSTEM

OBJECTIVE
- MISSION-SPECIFIC LIFE SUPPORT SYSTEMS ANALYSIS OF LONG DURATION EXTRA-TERRESTRIAL MISSIONS FOR LIFE SUPPORT SYSTEM INTEGRATION &TESTBED ACTIVITIES AT JSC AND RESEARCH PROGRAM AT ARC

ACCOMPLISHMENT
- DEVELOPED A RIGOROUS AND FLEXIBLE METHODOLOGY FOR SYSTEM AND TECHNOLOGY TRADES
- COMPLETED LUNAR OUTPOST SYSTEM AND TECHNOLOGY TRADE STUDIES USING SSF BASELINE TECHNOLOGY SET

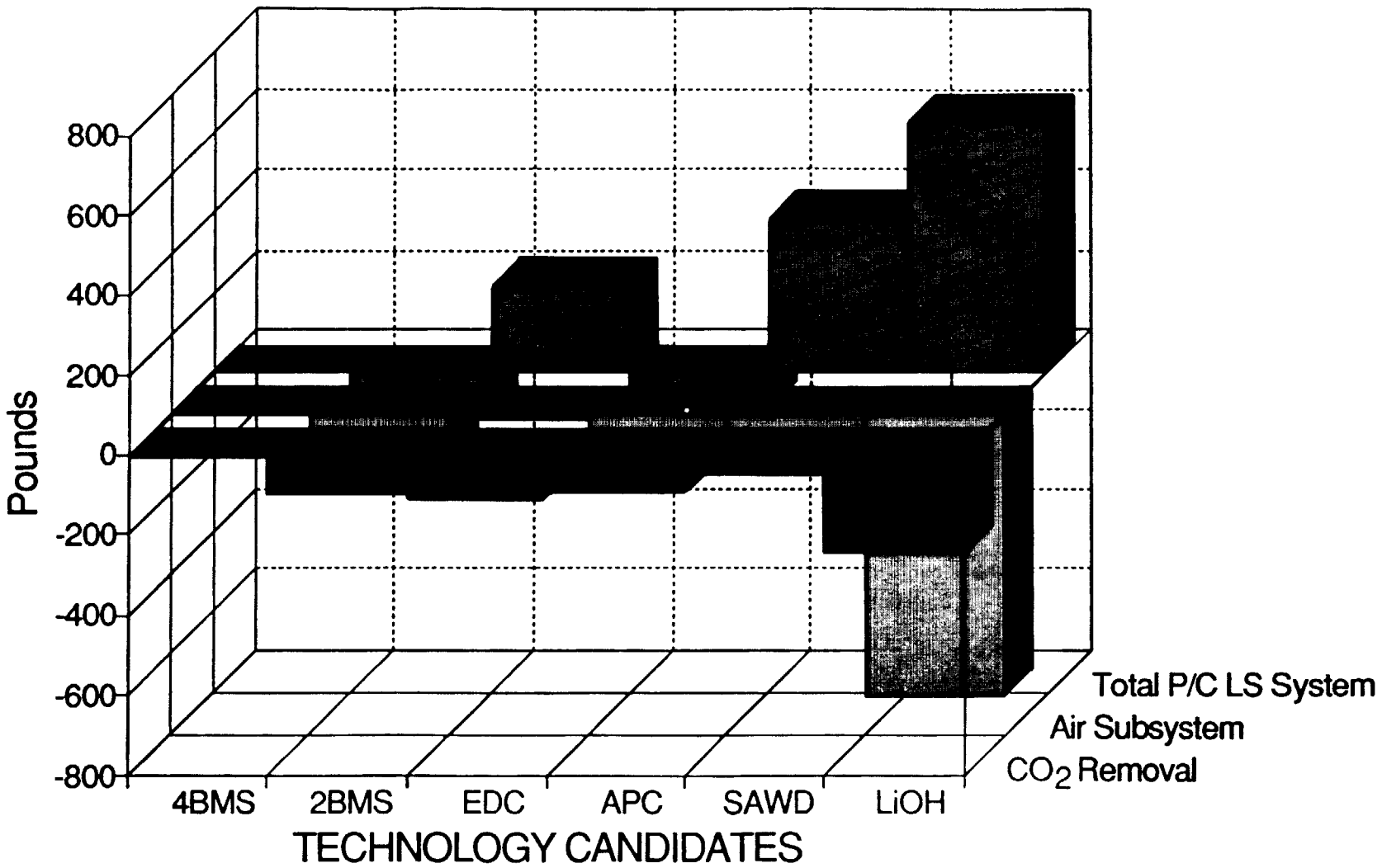
BENEFITS
- ENABLES MORE ACCURATE AND EFFICIENT PROJECT & PROGRAM PLANNING AND DECISION-MAKING IN TECHNOLOGY DEVELOPMENT AND SYSTEM ENGINEERING
- LUNAR HABITAT SYSTEMS ANALYSIS SHOWS NEW CO2 REMOVAL CONCEPTS (TWO-BED MOLECULAR SIEVE, AIR POLARIZED CELL) OFFER SYSTEM LEVEL WEIGHT SAVINGS OF 400-700 LBS OVER CURRENT CO2 REMOVAL TECHNOLOGIES (ELECTROCHEMICAL DEPOLARIZED CELL, SOLID AMINE, LITHIUM HYDROXIDE)

APPLICABLE MISSIONS
- SPACE STATION FREEDOM
- SHUTTLE ORBITER
- SPACE SUITS
- DOD MISSIONS

PLANETARY SURFACE FY91

Lunar Habitat I - P/C CLLS Tech. Trades

CO_2 Removal Weight Penalties w.r.t 4BMS

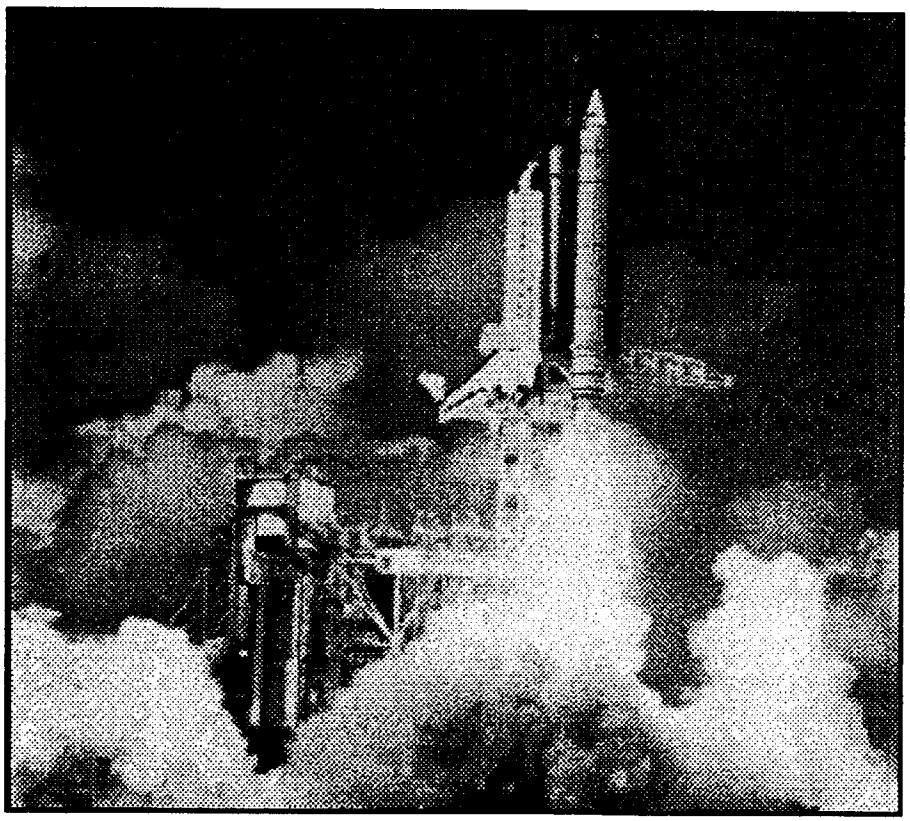


TRANSPORTATION

FOCUSSED PROGRAM

TRANSPORTATION TECHNOLOGY

PROVIDE TECHNOLOGIES THAT SUBSTANTIALLY INCREASE OPERABILITY, IMPROVE RELIABILITY, PROVIDE NEW CAPABILITIES, WHILE REDUCING LIFE CYCLE COSTS



- ENHANCE SAFETY, RELIABILITY, AND SERVICEABILITY OF CURRENT SPACE SHUTTLE
- PROVIDE TECHNOLOGY OPTIONS FOR NEW MANNED SYSTEMS THAT COMPLEMENT THE SHUTTLE AND ENABLE NEXT GENERATION VEHICLES WITH RAPID TURNAROUND AND LOW OPERATIONAL COSTS
- SUPPORT DEVELOPMENT OF ROBUST, LOW-COST HEAVY LIFT LAUNCH VEHICLES
- DEVELOP AND TRANSFER LOW-COST TECHNOLOGY TO SUPPORT COMMERCIAL ELV's AND UPPER STAGES
- IDENTIFY AND DEVELOP HIGH LEVERAGE TECHNOLOGIES FOR IN-SPACE TRANSPORTATION, INCLUDING NUCLEAR PROPULSION, THAT WILL ENABLE NEW CLASSES OF SCIENCE AND EXPLORATION MISSIONS

91-8048

Office of Aeronautics and Space Technology

NEW CFD TOOLS FOR TURBINE BLADE DESIGN

NASA — MSFC/LeRC — OAST

RP

SHOWN

- COMPUTATIONAL FLUID DYNAMICS (CFD) ANALYSIS OF TWO-STAGE GENERIC GAS GENERATOR TURBINE (GGGT) WITH IDENTIFICATION OF CONTRIBUTING ORGANIZATIONS, AND TRADITIONAL VS. ADVANCED BLADE DESIGNS

OBJECTIVE

- TO ENHANCE AND VALIDATE CFD TOOLS IN ORDER TO USE THEM TO DESIGN TURBINE BLADES

ACCOMPLISHMENT

- ENHANCED EXISTING CFD TOOLS TO ENABLE 3D BLADE ANALYSIS
- VALIDATED NEW CFD TOOLS BY DESIGNING ADVANCED GGGT BLADES (KNOWN TECHNOLOGY)
- APPLIED TOOLS TO SPACE TRANSPORTATION MAIN ENGINE (STME) TURBINE DESIGN
  - CREATED NOVEL DESIGN WHICH PERMITS SINGLE INSTEAD OF TWO-STAGE TURBINES (ONE BLADE ROW INSTEAD OF TWO)

BENEFITS

- ENABLES IMPROVED TURBINE BLADE ANALYSIS FOR FUTURE ENGINE DESIGN
- NEW BLADE DESIGN OFFERS
  - 10% INCREASE IN BLADE EFFICIENCY
  - 55% REDUCTION IN BLADE COUNT
  - ESTIMATED $71M LIFE CYCLE COST SAVINGS

APPLICABLE MISSIONS

- STME FOR NATIONAL LAUNCH SYSTEM OR HEAVY LIFT LAUNCH VEHICLES
- ADVANCED EXPANDER CYCLE ENGINES FOR UPPER STAGES AND OTHER SPACE TRANSPORTATION VEHICLES
- ADVANCED REUSABLE ENGINES FOR ADVANCED MANNED LAUNCH SYSTEM

CONSORTIUM FOR CFD APPLICATION IN PROPULSION TECHNOLOGY

Turbine Stage Technology Team-Baseline GGGT aerodynamic analyses

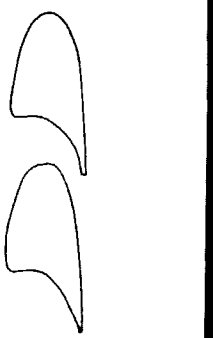
LeRC
Inverse design code

SRA
3D N/S tip lkg

MSFC
3D N/S

Traditional Blade Design

Advanced Concept Blade Design



UTRC
2D N/S

ARC
Unsteady 2D N/S

P&W
Multi-stage 3D Euler

NEW TECHNOLOGY MAIN COMBUSTION CHAMBER (MCC)

NASA — MSFC — OAST — RP

SHOWN

- ADVANCED VERSION OF MCC FOR VERIFICATION TESTING IN SPACE SHUTTLE MAIN ENGINE (SSME) TECHNOLOGY TEST BED

OBJECTIVE

- TO DEVELOP AND VERIFY ADVANCED MANUFACTURING TECHNOLOGIES THAT WILL YIELD READILY INSPECTABLE AND CERTIFIABLE MCCs WHILE SIGNIFICANTLY REDUCING FABRICATION COST AND TIME

ACCOMPLISHMENT

- DEVELOPED TWO ADVANCED MANUFACTURING TECHNOLOGIES FOR MCC LINERS: VACUUM PLASMA SPRAY (VPS) AND FORMED PLATELET (FP)
- DEVELOPED ADVANCED MANUFACTURING TECHNOLOGY FOR MCC JACKET: PRECISION CASTING
- VERIFIED VPS MANUFACTURING PROCESS THROUGH SUCCESSFUL FABRICATION AND TEST OF 40K-LBS-THRUST COMBUSTION CHAMBER

BENEFITS

- 67% REDUCTION IN PRODUCTION COST OF MCC ($1M vs. $3.2M)
- 67% REDUCTION IN PRODUCTION TIME (50 Weeks vs. 150 Weeks)
- INCREASES MCC QUALITY (FEWER WELDS, 100% INSPECTABLE) COMPARED TO STATE-OF-THE-ART SSME (MANY UNINSPECTABLE WELDS)
- IMPROVES HEAT TRANSFER WHICH EXTENDS LIFE OF MCC

APPLICABLE MISSIONS

- SSME EVOLUTION
- SPACE TRANSPORTATION MAIN ENGINE (STME) FOR NATIONAL LAUNCH SYSTEM OR HEAVY LIFT LAUNCH VEHICLES
- ADVANCED EXPANDER CYCLE ENGINES FOR UPPER STAGES AND OTHER SPACE TRANSPORTATION VEHICLES
- ADVANCED REUSABLE ENGINES FOR ADVANCED MANNED LAUNCH SYSTEM

HIGH-ASPECT-RATIO COOLING CHANNEL DESIGNS

NASA — LeRC — OAST

RP

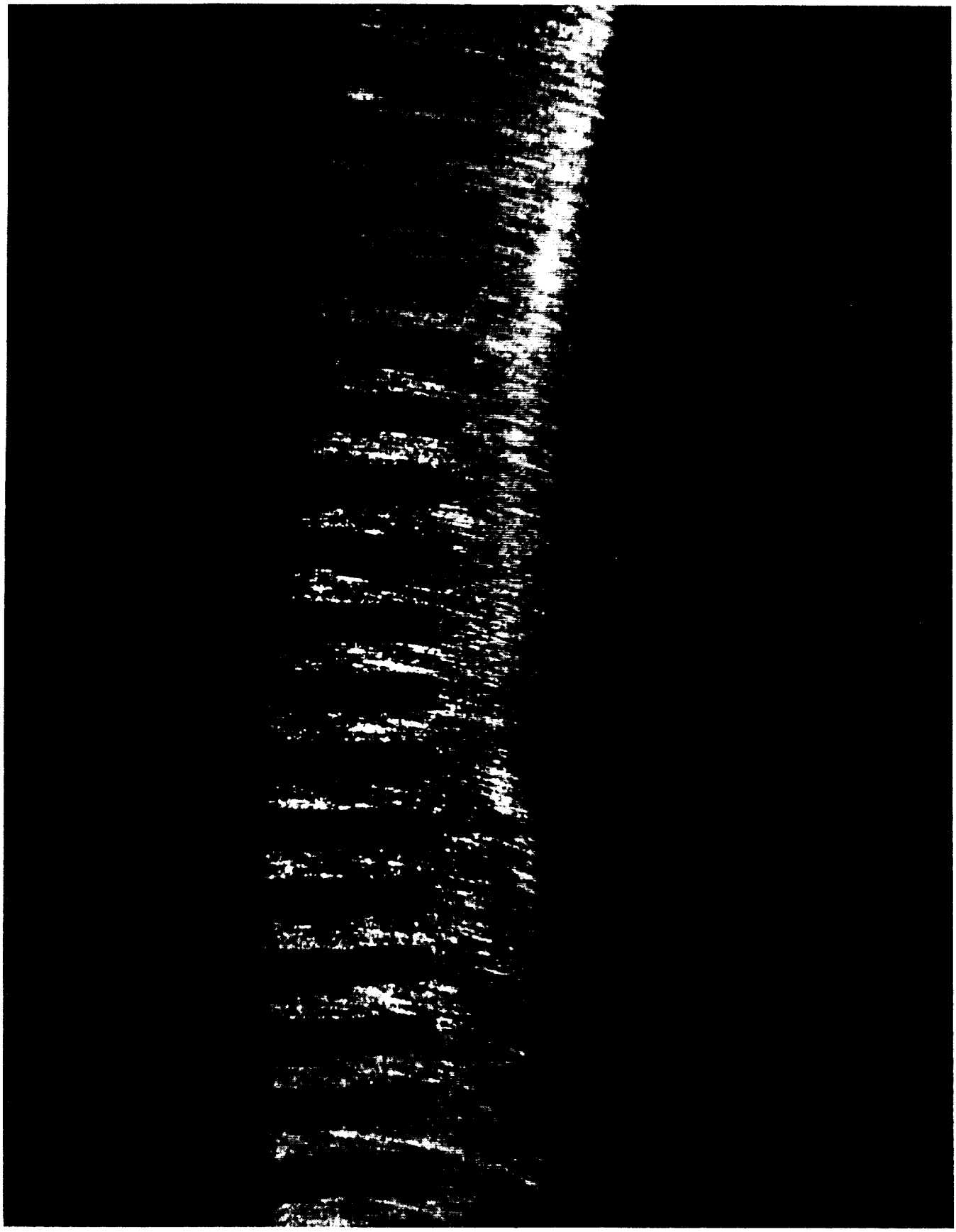
SHOWN
- UNFINISHED THROAT CROSS-SECTION OF SUBSCALE HIGH-ASPECT-RATIO COMBUSTION CHAMBER LINER WITH 400 HIGH-ASPECT-RATIO (6.0) COOLING PASSAGES

OBJECTIVE
- TO FABRICATE HIGH-ASPECT-RATIO COOLING CHANNEL
- TO VERIFY AND CHARACTERIZE THE ADVANTAGES OF USING HIGH-ASPECT-RATIO COOLING PASSAGES IN HIGH PRESSURE ROCKET CHAMBERS

ACCOMPLISHMENT
- FABRICATED HIGH-ASPECT-RATIO COOLING CHANNEL IN SUBSCALE THRUST CHAMBER
- VERIFIED AND CHARACTERIZED CHANNEL
  - BETTER COOLING: ACHIEVED 530°F REDUCTION IN HOT GAS SIDE WALL TEMPERATURE COMPARED TO STATE-OF-THE-ART 0.75-ASPECT-RATIO COOLING CHANNELS
  - LONGER LIFE: NO FATIGUE DAMAGE AFTER 440 THERMAL CYCLES
  - LESS COOLANT FLOW REQUIRED: ACHIEVED 200°F REDUCTION IN HOT GAS SIDE WALL TEMPERATURE AFTER REDUCING COOLANT FLOW BY 50%

BENEFITS
- BETTER COOLING ENABLES SIGNIFICANT INCREASE IN COMBUSTION CHAMBER LINER THERMAL FATIGUE LIFE
- LESS COOLANT FLOW ENABLES REDUCED POWER REQUIREMENTS FOR TURBOMACHINERY

APPLICABLE MISSIONS
- SPACE SHUTTLE MAIN ENGINE (SSME) EVOLUTION
- SPACE TRANSPORTATION MAIN ENGINE (STME) FOR NATIONAL LAUNCH SYSTEM OR HEAVY LIFT LAUNCH VEHICLES
- ADVANCED EXPANDER CYCLE ENGINES FOR UPPER STAGES AND OTHER SPACE TRANSPORTATION VEHICLES
- ADVANCED REUSABLE ENGINES FOR ADVANCED MANNED LAUNCH SYSTEM

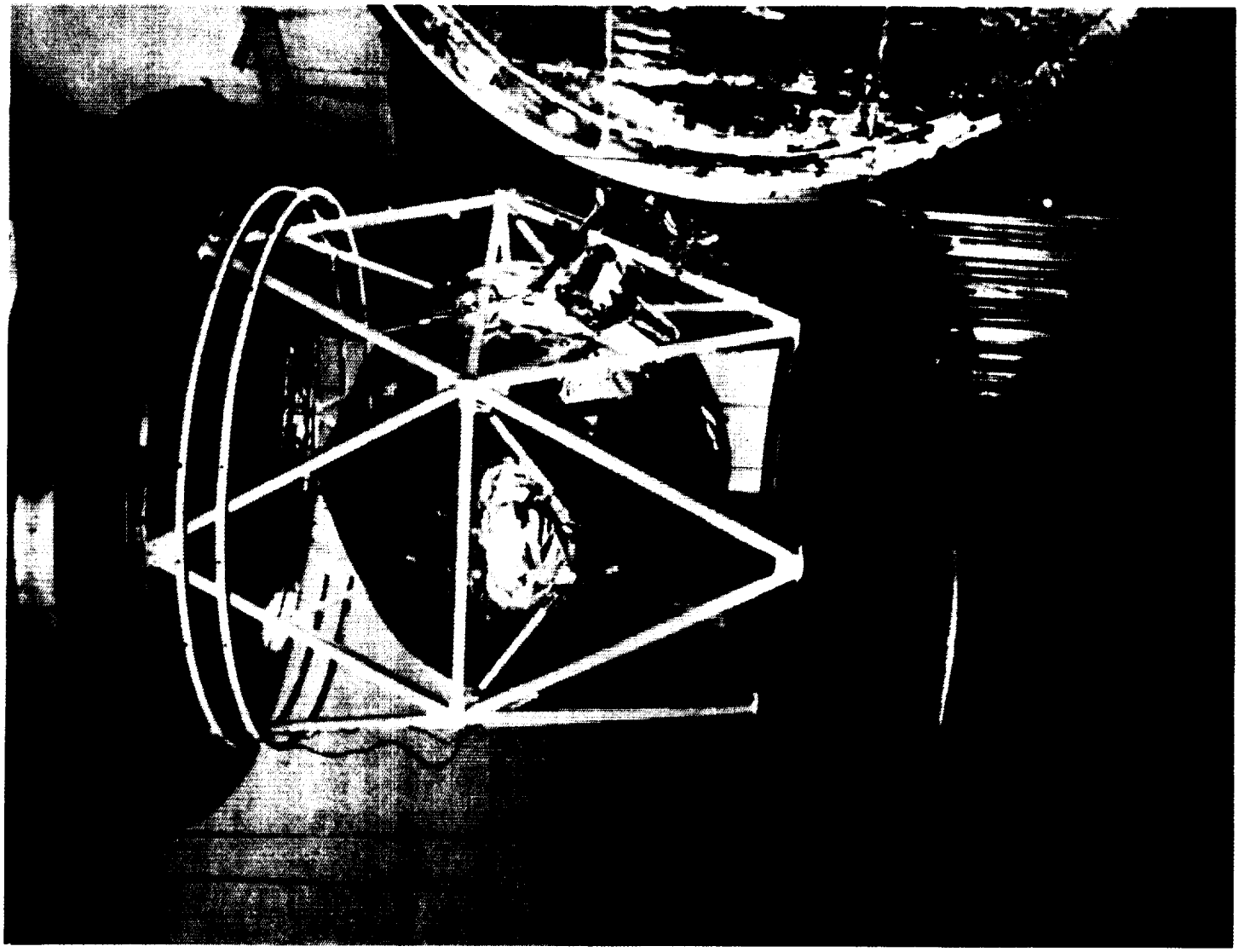


LOW COST THRUST CHAMBER CRITICAL TEST

NASA — LeRC — OAST

RP

SHOWN	● TRW LOW-COST THRUST CHAMBER ASSEMBLY UNDER TEST AT LeRC ROCKET ENGINE TEST FACILITY AS PART OF THE SPACE ACT COOPERATIVE AGREEMENT
OBJECTIVE	● TO DEMONSTRATE THAT PREVIOUSLY DEVELOPED PINTLE INJECTOR (ROCKET ENGINE COMPONENT) CAN OPERATE STABLY WITH HIGH-ENERGY LIQUID HYDROGEN/LIQUID OXYGEN (LH2/LO2) PROPELLANTS
ACCOMPLISHMENT	● DEMONSTRATED STABLE OPERATION OF PINTLE INJECTOR WITH LH2/LO2 PROPELLANTS IN 16.5K-LBS-THRUST THRUST CHAMBER ASSEMBLY (20 RUNS OF 2 SEC OR LESS AT ACCEPTABLE COMBUSTION EFFICIENCY LEVELS OF 96 PERCENT)
BENEFITS	● PROVIDES LOW-COST EXPENDABLE REPLACEMENT FOR HIGH-COST PROPULSION HARDWARE IN CURRENT EXPENDABLE LAUNCH VEHICLE (ELV) FLEET ● ENHANCES U.S. COMPETITIVE POSITION IN WORLD MARKET
APPLICABLE MISSIONS	● EARTH/ORBIT MISSION EXPENDABLE LAUNCH VEHICLE (ELV) BOOSTER-STAGE AND UPPER-STAGE PROPULSION



CERAMIC COMPOSITE ENGINE PARTS

NASA — LeRC — OAST

RP

SHOWN

- TESTING OF CERAMIC COMPOSITE TURBINE BLADES AT HIGH TEMPERATURE

OBJECTIVE

- TO DEVELOP FABRICATION PROCESS FOR CERAMIC COMPOSITE COMPONENTS
- TO APPLY CERAMIC COMPOSITE COMPONENTS TO HIGH TEMPERATURE ROCKET ENGINE PARTS

ACCOMPLISHMENT

- DEVELOPED AND DEMONSTRATED FABRICATION METHODS FOR CARBON FIBER/SILICON CARBIDE (C/SiC) MATRIX AND SILICON CARBIDE FIBER/SILICON NITRIDE (SiC/Si_3N_4) MATRIX MATERIALS
- APPLIED FABRICATION PROCESSES TO HIGH TEMPERATURE ROCKET ENGINE PART (TURBINE BLADE)
  - DEMONSTRATED TURBINE BLADE DURABILITY, RELIABILITY, AND DAMAGE TOLERANCE UNDER SEVERE THERMAL SHOCK CONDITIONS

BENEFITS

- OFFERS HIGH TEMPERATURE CAPABILITY AND STRUCTURAL STRENGTH IN AGGRESSIVE ENVIRONMENTS (THERMAL TRANSIENTS) COMPARED TO STATE-OF-THE-ART SUPERALLOY METAL BLADES
  - DRAMATIC INCREASES ENGINE EFFICIENCY AND PERFORMANCE
  - DRAMATIC INCREASES ENGINE LIFE

APPLICABLE MISSIONS

- ADVANCED REUSABLE ENGINES FOR ADVANCED MANNED LAUNCH SYSTEM (AMLS)

NASA
C-91-01076

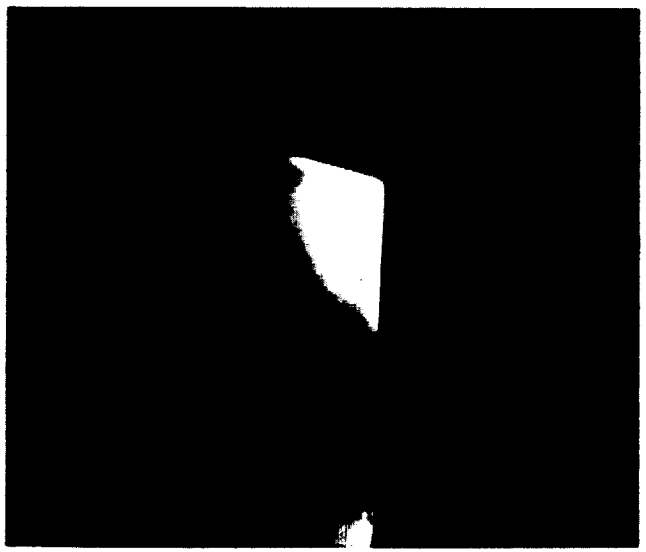
AEROSPACE TECHNOLOGY DIRECTORATE

CERAMICS BRANCH

NASA
Lewis Research Center

Fiber Reinforced Ceramic Matrix Composite Airfoil Shapes Survive Severe Thermal Shock

SiC/Si_3N_4



C/SiC

CD-91-53857

CERAMIC BALLS FOR LONG-LIFE BALL BEARINGS

NASA — MSFC — OAST

RP

SHOWN
- SILICON NITRIDE CERAMIC BALLS AFTER 7+ HOURS OF OPERATION IN BEARING TESTER COMPARED TO STANDARD SPACE SHUTTLE MAIN ENGINE (SSME) 440C METAL ALLOY BALLS AFTER 15+ MINUTES OF OPERATION

OBJECTIVE
- TO DEVELOP CERAMIC BALL BEARING FABRICATION PROCESS THAT WILL EXTEND HIGH LOAD BALL BEARING LIFE FROM MINUTES TO MANY HOURS

ACCOMPLISHMENT
- DEVELOPED SILICON NITRIDE BALL BEARING FABRICATION PROCESS
- DEMONSTRATED 7+ HOURS LIFE OF SILICON NITRIDE BALLS IN BEARING TESTER UNDER LOADING CONDITIONS THAT EXCEED THOSE IN SSME

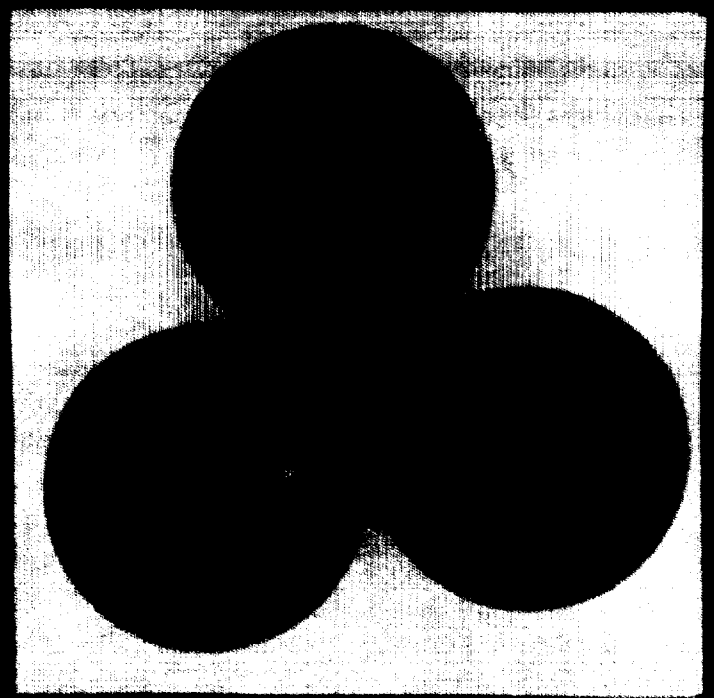
BENEFITS
- INCREASE IN BALL BEARING LIFETIME FROM MINUTES TO SEVERAL HOURS
  - ELIMINATES FREQUENT BEARING CHANGE OUT CURRENTLY EXPERIENCED BY SSME (CHANGEOUTS COST APPROXIMATELY $1M EACH)

APPLICABLE MISSIONS
- SSME EVOLUTION
- ADVANCED REUSABLE ENGINES FOR ADVANCED MANNED LAUNCH SYSTEM

MSFC BSMT Bearing Tester

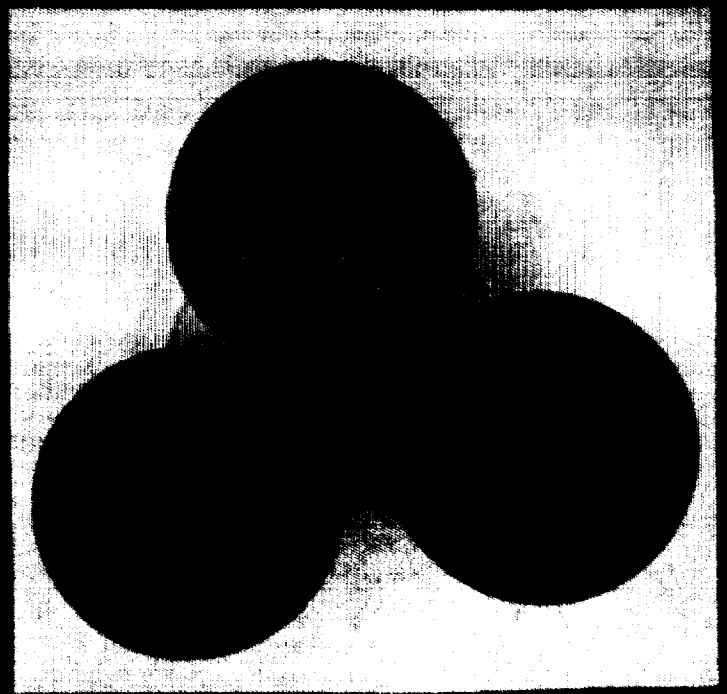
3 - 57 Silicon Nitride / 440 C Balls
57 mm (2.25 in) Bore Bearing

Unit 3, Build 2
440 C Baseline



10 Min at 30,000 rpm
Average Ball Wear = .14 mm
(.0055 in)

Unit 2, Build 12
Silicon Nitride



7 hours, 8 minutes at 30,000 rpm
Average Ball Wear = .018 mm
(.0007 in)

NUCLEAR ELECTRIC PROPULSION (NEP)

NASA — LeRC — OAST

RP

SHOWN

- CONCEPT FOR NUCLEAR ELECTRIC ROCKET APPROACHING MARS ORBIT. A SMALL MARS EXCURSION VEHICLE WOULD DESCEND FROM THIS NUCLEAR ELECTRIC VEHICLE DOWN TO THE PLANET'S SURFACE. AFTER COMPLETING SURFACE EXPLORATION, IT WOULD RETURN TO SPACE AND RENDEZVOUS WITH THE NUCLEAR ELECTRIC SPACECRAFT FOR TRANSIT BACK TO EARTH.

OBJECTIVE

- TO DEVELOP AND DEMONSTRATE FOCUSSED NEP SYSTEMS TECHNOLOGY WHICH
  - COMPLIES WITH SOUND SAFETY AND ENVIRONMENTAL POLICIES
  - MEETS MISSION REQUIREMENTS OF USER CODES

ACCOMPLISHMENT

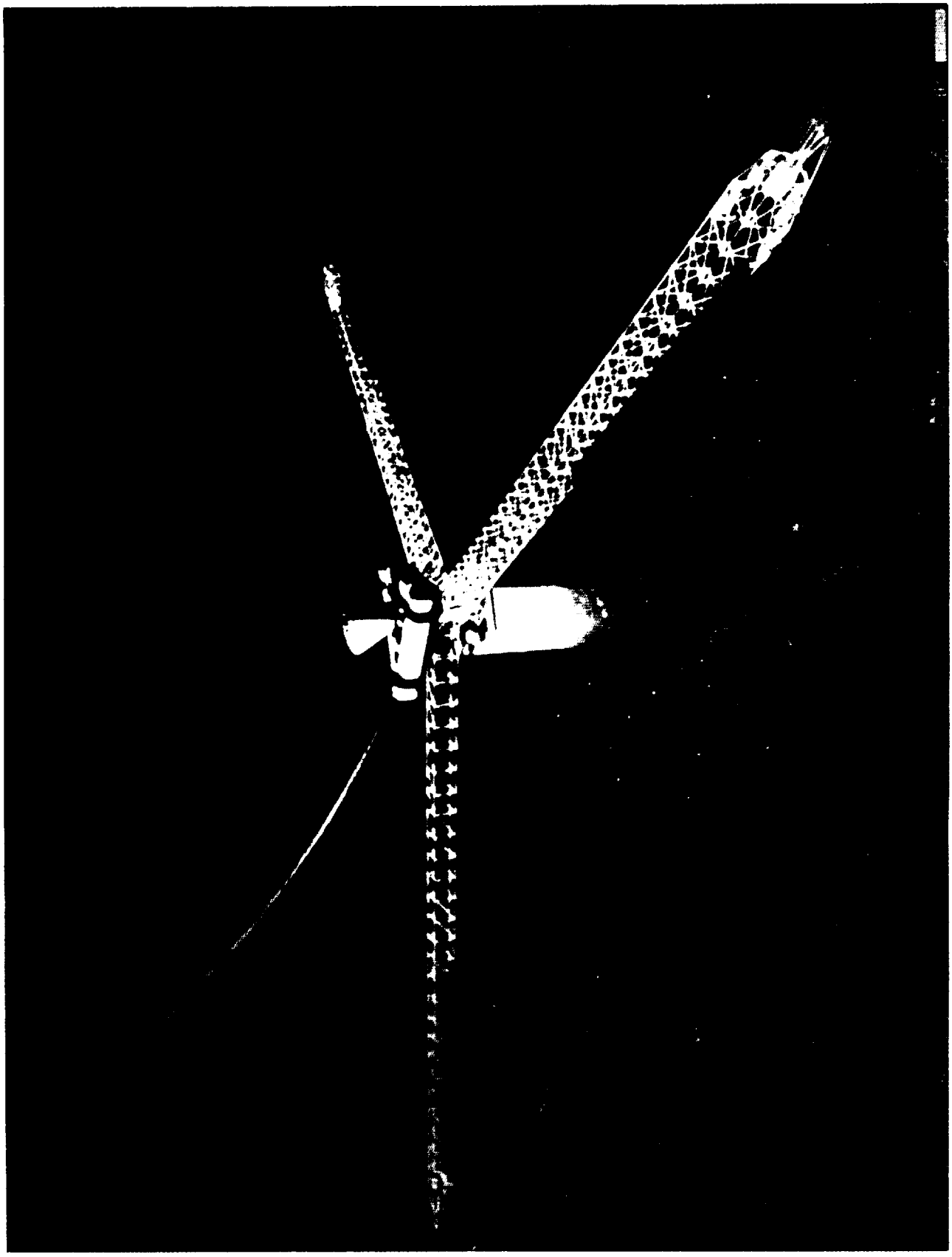
- COMPLETED GOVERNMENT/INDUSTRY NEP SYSTEMS EVALUATION
  - COMPLETED MISSION STUDIES TO SHOW BENEFITS OF NEP FOR MARS PILOTED MISSION AND ROBOTIC PLANETARY SCIENCE MISSIONS
- DEVELOPED CONCEPT FOR MODULAR 5MW NEP SYSTEM FOR CARGO AND PILOTED MISSIONS

BENEFITS

- ENABLES LOWER MISSION RESUPPLY MASS
- PROVIDES HIGH LEVELS OF ON-BOARD POWER WHICH CAN BE USED BY SYSTEMS OTHER THAN PROPULSION
- PROVIDES WIDER LAUNCH WINDOWS
- ENABLES LOWER DEVELOPMENT COSTS THROUGH COMMONALITY WITH SURFACE NUCLEAR POWER REACTOR

APPLICABLE MISSIONS

- ROBOTIC PLANETARY SCIENCE MISSIONS
- MARS CARGO AND PILOTED MISSIONS



NUCLEAR THERMAL PROPULSION (NTP)

SHOWN

- CONCEPT FOR NUCLEAR THERMAL ROCKET APPROACHING MARS ORBIT. A SMALL MARS EXCURSION VEHICLE WOULD DESCEND FROM THIS NUCLEAR SPACECRAFT DOWN TO THE PLANET'S SURFACE. AFTER COMPLETING SURFACE EXPLORATION, IT WOULD RETURN TO SPACE AND RENDEZVOUS WITH THE NUCLEAR THERMAL SPACECRAFT FOR TRANSIT BACK TO EARTH.

OBJECTIVE

- TO DEVELOP AND DEMONSTRATE FOCUSSED NTP SYSTEMS TECHNOLOGY WHICH
  - COMPLIES WITH SOUND SAFETY AND ENVIRONMENTAL POLICIES
  - MEETS CODE X MISSION REQUIREMENTS

ACCOMPLISHMENT

- COMPLETED GOVERNMENT/INDUSTRY NTP SYSTEMS EVALUATION
  - COMPLETED PRELIMINARY SELECTION OF 3 NTP CONCEPTS FOR FURTHER STUDY (NERVA DERIVATIVE, PARTICLE BED, CERMET)
- DEVELOPED CONCEPT FOR COMMON MODULAR NUCLEAR THERMAL ROCKET STAGE COMPONENTS WHICH SATISFIES LUNAR AND MARS CARGO AND PILOTED MISSION REQUIREMENTS

BENEFITS

- ENABLES SHORTER TRANSIT TIMES
- REDUCES INITIAL MASS INTO LOW EARTH ORBIT (IMLEO) REQUIREMENTS BY 50% COMPARED TO CHEMICAL SYSTEMS
- PROVIDES WIDER LAUNCH WINDOWS
- ENHANCES OPERATIONAL FLEXIBILITY (CREW SAFETY)

APPLICABLE MISSIONS

- ROBOTIC PLANETARY SCIENCE MISSIONS
- MARS CARGO AND PILOTED MISSIONS

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C-91-05898

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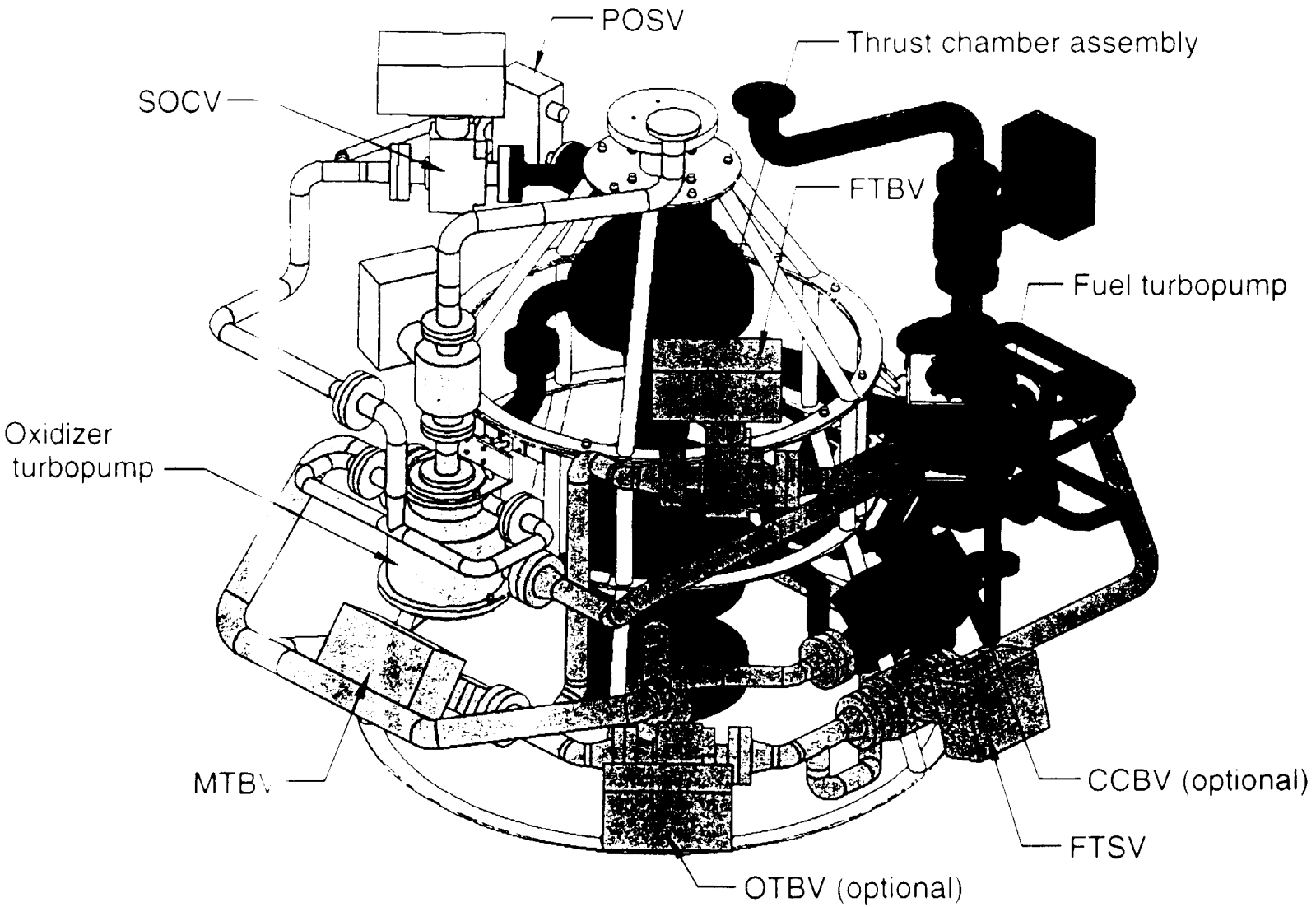
ADVANCED EXPANDER TESTBED (AETB)

NASA — LeRC — OAST

RP

SHOWN	● ADVANCED EXPANDER TESTBED CRYOGENIC ENGINE
OBJECTIVE	● TO DEVELOP ENGINE SYSTEM TECHNOLOGY BASE IN PREPARATION FOR DEVELOPMENT OF THE NEXT SPACE OR UPPERSTAGE CHEMICAL ROCKET ENGINE
ACCOMPLISHMENT	● COMPLETED TESTBED CRYOENGINE PRELIMINARY DESIGN
BENEFITS	● VALIDATES COMPONENT AND ENGINE DESIGN AND ANALYSIS ● IDENTIFIES ENGINE SYSTEM EFFECTS (e.g. COMPONENT INTERACTIONS, SYSTEM DYNAMICS, CONTROL LOGICS) ● PROVIDES A "HOST DEVICE" TO EVALUATE ALTERNATE COMPONENTS AND HEALTH MONITORING SYSTEMS IN AN ENGINE ENVIRONMENT
APPLICABLE MISSIONS	● SPACE TRANSFER VEHICLE CHEMICAL PROPULSION ENGINES ● UPPERSTAGE CHEMICAL ENGINES FOR EXPENDABLE LAUNCH VEHICLES

AETB ASSEMBLY



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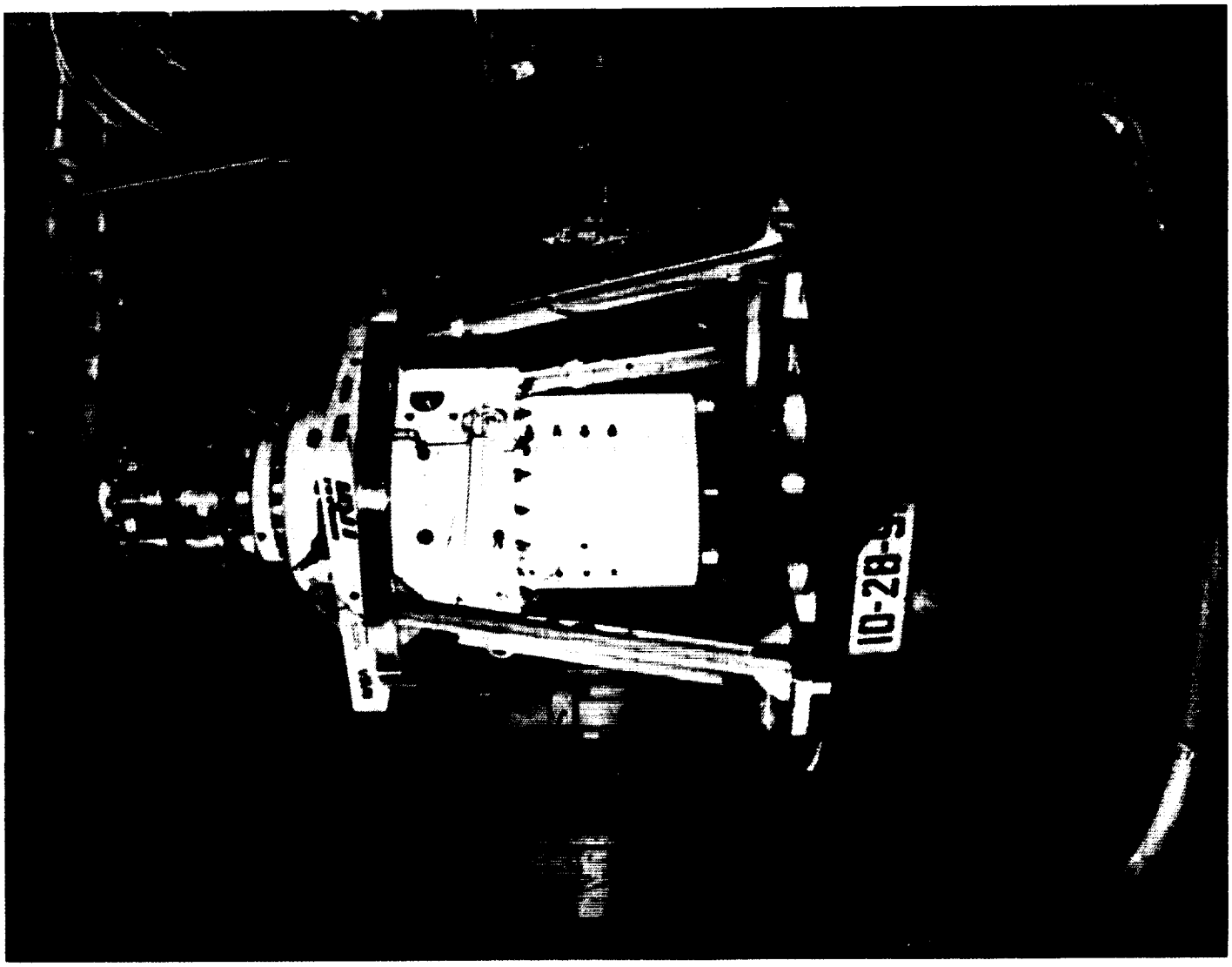
MULTILAYER INSULATION (MLI) TECHNOLOGY

NASA = LeRC — OAST

RP

SHOWN	● INSTALLATION OF FLIGHT TYPE LIQUID HYDROGEN TANK WITH 34 LAYERS OF MLI IN TEMPERATURE CONTROLLED SHROUD PRIOR TO VACUUM TESTS
OBJECTIVE	● DETERMINE THERMAL PERFORMANCE OF AN MLI SYSTEM IN TEMPERATURE RANGE ANTICIPATED FOR LEO AND LUNAR MISSIONS
ACCOMPLISHMENT	● DETERMINED MLI THERMAL PERFORMANCE OVER SPECIFIED TEMPERATURE RANGE ● SIMULATED LUNAR TEMPERATURE PROFILE (FROM SURVEYOR DATA) ● DETERMINED TRANSIENT MLI THERMAL PERFORMANCE DURING SIMULATED LUNAR SUNRISE
BENEFITS	● ENABLES MISSION SPECIFIC PERFORMANCE PREDICTIONS (e.g. 1- 2 %/MONTH BOILOFF AT LUNAR SURFACE) VIA VALIDATED MODELS ● 20-30% LAUNCH MASS REDUCTION FOR LUNAR MISSIONS UP TO 6 MONTHS, USING FULLY CRYOGENIC SYSTEM COMPARED TO STATE-OF-THE-ART STORABLE ASCENT AND RETURN
APPLICABLE MISSIONS	● LEO TO GEO TRANSFER MISSIONS ● LUNAR MISSIONS (INCLUDING ASCENT AND RETURN)

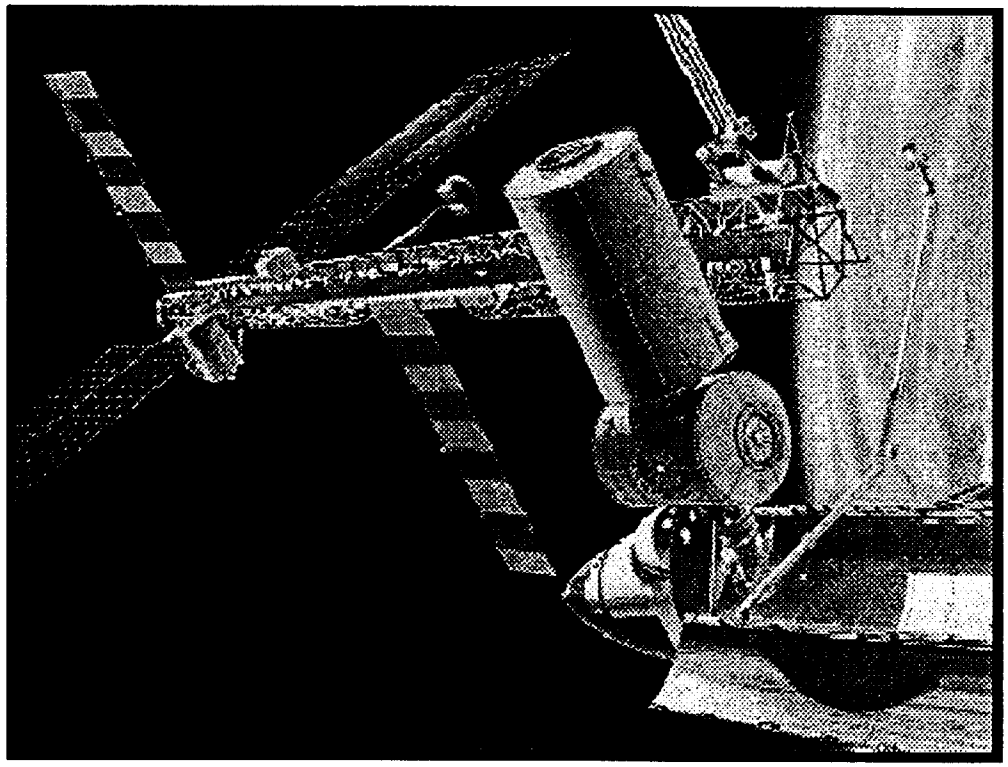


PLATFORMS

FOCUSSED PROGRAM

SPACE PLATFORMS TECHNOLOGY

DEVELOP TECHNOLOGIES TO INCREASE ON-ORBIT MISSION EFFICIENCY AND DECREASE LIFE CYCLE COSTS FOR FUTURE MANNED AND UNMANNED SCIENCE, EXPLORATION & COMMERCIAL MISSIONS.



- DEVELOP TECHNOLOGIES THAT WILL DECREASE LAUNCH WEIGHT AND INCREASE THE EFFICIENCY OF SPACE PLATFORM FUNCTIONAL CAPABILITIES
- DEVELOP TECHNOLOGIES THAT WILL INCREASE HUMAN PRODUCTIVITY AND SAFETY OF MANNED MISSIONS
- DEVELOP TECHNOLOGIES THAT WILL INCREASE MAINTAINABILITY AND REDUCE LOGISTICS RESUPPLY OF LONG DURATION MISSIONS
- IDENTIFY AND DEVELOP FLIGHT EXPERIMENTS IN ALL TECHNOLOGY AND THRUST AREAS THAT WILL BENEFIT FROM THE UTILIZATION OF SSF FACILITIES

Office of Aeronautics and Space Technology

CONTROLS-STRUCTURES INTERACTION (CSI)

NASA — LaRC — OAST

RM

SHOWN
- INITIAL CSI PLATFORM TESTBED SUSPENDED IN THE LABORATORY AT LANGLEY

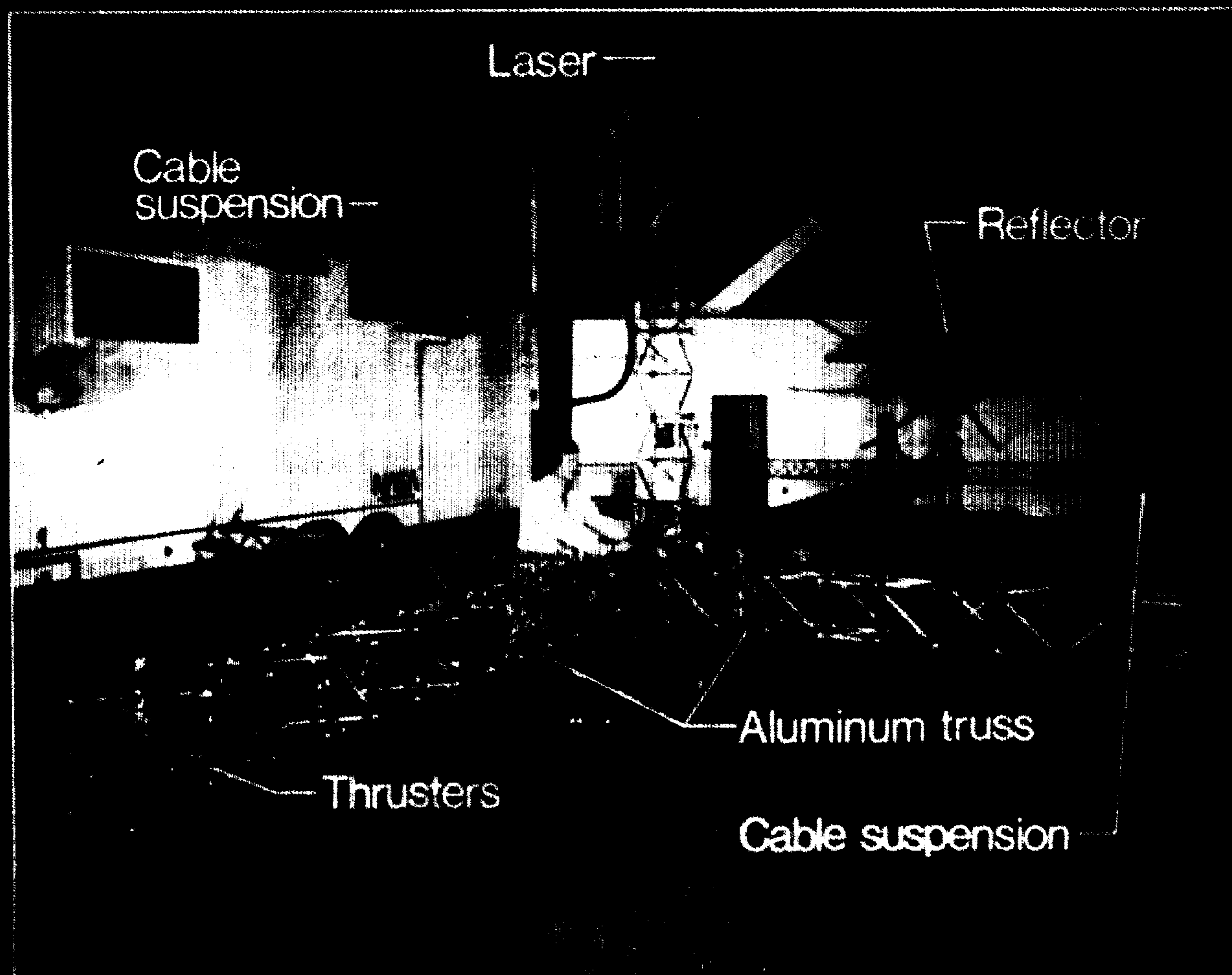
OBJECTIVE
- TO DEVELOP METHODS TO DESIGN, ANALYZE, AND TEST LIGHTWEIGHT, HIGH-PERFORMANCE, CONTROLLED STRUCTURES
- TO VALIDATE THE TECHNOLOGY WITH GROUND AND FLIGHT DEMONSTRATIONS

ACCOMPLISHMENT
- PERFORMED GROUND-TEST CSI TECHNOLOGY EXPERIMENT WHICH DEMONSTRATED 20-30X INCREASE IN DAMPING
- PERFORMED CSI ANALYTICAL STUDIES WHICH SHOWED SIGNIFICANTLY IMPROVED REMOTE SENSING PRECISION POINTING JITTER FOR LARGE SPACE ANTENNAS

BENEFITS
- FACTOR OF 500 JITTER REDUCTION FOR 20-80M ANTENNAS
- DECREASED INTERACTION AMONG POINTING INSTRUMENTS ON MULTI-PAYLOAD PLATFORMS
- INCREASED POINTING PRECISION

APPLICABLE MISSIONS
- MISSION TO PLANET EARTH
- SPACE STATION FREEDOM ASSEMBLY
- SHUTTLE REMOTE MANIPULATOR SYSTEM OPERATIONS
- ADVANCED COMMUNICATION SPACECRAFT

THE PHASE-ZERO EVOLUTIONARY MODEL: A CONTROLS-STRUCTURES INTERACTION TESTBED



HYBRID-SCALE MODEL OF SPACE STATION FREEDOM (SSF) CONFIGURATION

NASA — LaRC — OAST

RM

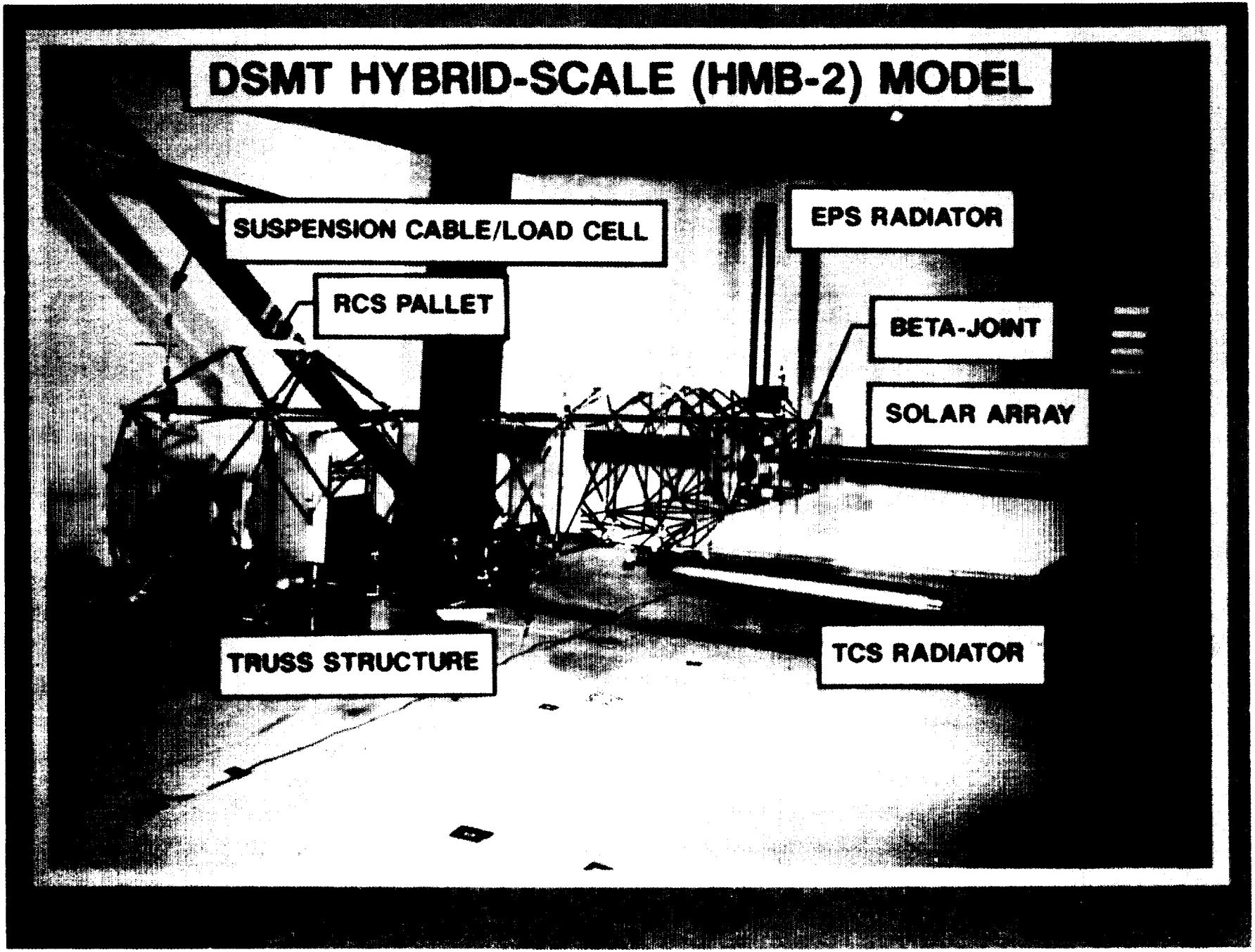
SHOWN
- HYBRID-SCALE SSF MODEL (HMB-2, PRECURSOR TO HMB-15)

OBJECTIVE
- TO DEVELOP DYNAMIC GROUND VERIFICATION TESTING METHODS OF LARGE, FLEXIBLE SPACECRAFT VIA SMALLER SCALE MODELS
- TO VALIDATE GROUND VERIFICATION TESTING METHODS BY CORRELATING THEM WITH ON-ORBIT DATA

ACCOMPLISHMENT
- DEVELOPED SCALE MODEL (HMB-2) FOR GROUND VERIFICATION TESTING
  - COMPLETED CRITICAL COMPONENT TESTING AND MODEL UPDATING
  - COMPLETED INITIAL VIBRATION TEST ON SUSPENDED MODEL
- ACQUIRED PARTS FOR HMB-15 SSF CONFIGURATION OF ERECTABLE TRUSS DESIGN (MODULES AND SOLAR ARRAYS)

BENEFITS
- SCALE MODEL ANALYSIS AND TESTING WILL ELIMINATE THE NEED TO TEST FULL-SCALE SPACECRAFT

APPLICABLE MISSIONS
- MISSION TO PLANET EARTH
- SPACE STATION FREEDOM ASSEMBLY
- REMOTE MANIPULATOR SYSTEM OPERATIONS
- ADVANCED COMMUNICATION SPACECRAFT



SIMULATED EVA ASSEMBLY OF TRUSS STRUCTURE AND PANELS

RM

SHOWN

- NEUTRAL BUOYANCY ENVIRONMENT TESTS FOR PRECISION SEGMENTED REFLECTOR PANEL-TO-TRUSS ATTACHMENT (LEFT) AND PANEL REMOVAL AND REPLACEMENT (RIGHT)

OBJECTIVE

- TO EVALUATE IN A SIMULATED WEIGHTLESS ENVIRONMENT:
  - PROCEDURES AND HARDWARE FOR THE ATTACHMENT OF PRECISION REFLECTOR PANELS TO A SUPPORT TRUSS STRUCTURE
  - A TECHNIQUE FOR THE REMOVAL AND REPLACEMENT OF A DAMAGED PANEL

ACCOMPLISHMENT

- EVALUATED TWO DESIGNS OF PANEL ATTACHMENT HARDWARE IN NEUTRAL BUOYANCY ENVIRONMENT OF McDONNELL DOUGLAS UNDERWATER TEST FACILITY
- DEVELOPED SPECIAL PURPOSE PANEL REMOVAL AND REPLACEMENT TOOL AND DEMONSTRATED ITS UTILITY IN NEUTRAL BUOYANCY

BENEFITS

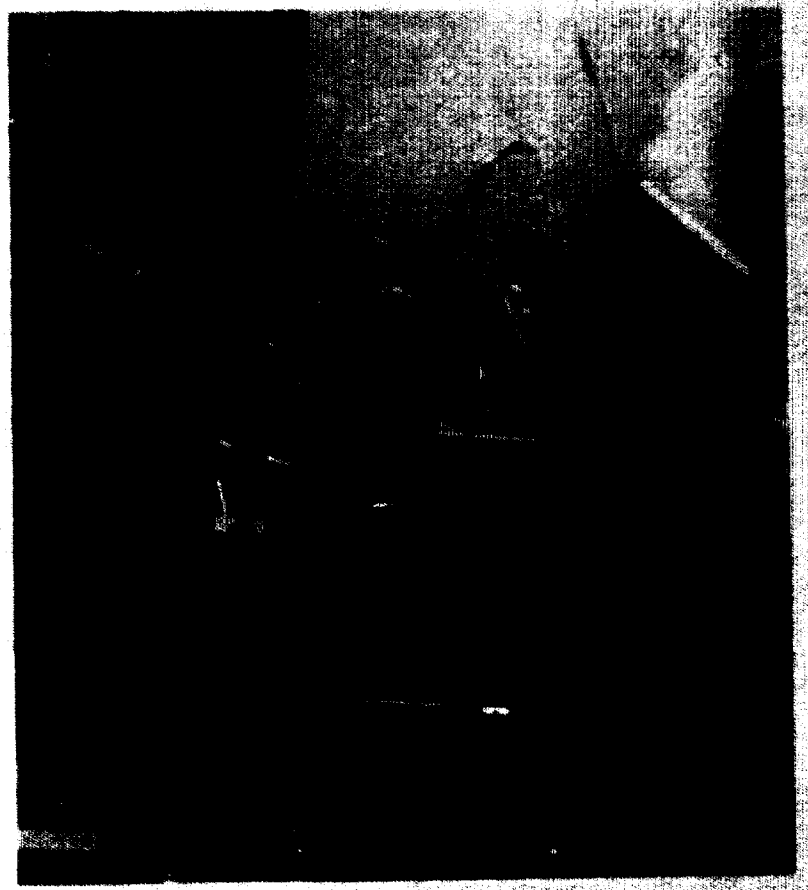
- DEMONSTRATED EFFICIENCY AND EASE OF OPERATIONS IN ATTACHING PRECISION PANELS TO A SUPPORTING STRUCTURE
  - PRELIMINARY RESULTS SHOW PANEL ATTACHMENT TIMES OF 1-2 MINUTES AS COMPARED TO PROJECTED TIMES OF 15-30 MINUTES
- PANEL REMOVAL AND REPLACEMENT TOOL ENABLES ALL CRITICAL EVA OPERATIONS TO BE PERFORMED FROM BEHIND THE PANEL, THUS MINIMIZING RISK OF PANEL SURFACE DAMAGE
  - PRELIMINARY RESULTS SHOW PANEL REMOVAL AND REPLACEMENT TIMES OF APPROXIMATELY 10 MINUTES AS COMPARED TO PROJECTED TIMES OF 1-2 HOURS

APPLICABLE MISSIONS

- LARGE ANTENNA CONSTRUCTION
- LARGE SOLAR COLLECTORS

PRECISION SEGMENTED REFLECTOR PANEL-TO-TRUSS ATTACHMENT HARDWARE AND PROCEDURES VERIFIED IN NEUTRAL BUOYANCY TESTS

Panel Attachment



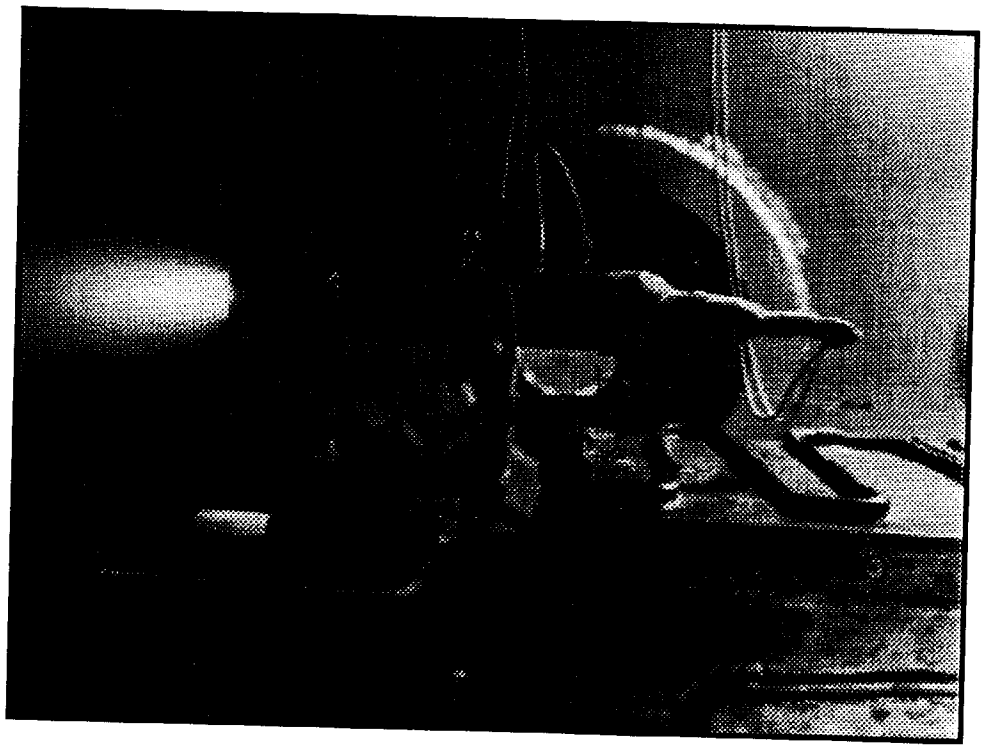
Panel Removal and Replacement

NASA Langley Research Center — Structural Mechanics Division

RESEARCH &TECHNOLOGY BASE

SPACE RESEARCH & TECHNOLOGY BASE

CONDUCT RESEARCH TO IDENTIFY, DEVELOP AND VALIDATE HIGH-LEVERAGE CONCEPTS IN KEY TECHNOLOGY DISCIPLINES (TECHNOLOGY PUSH)



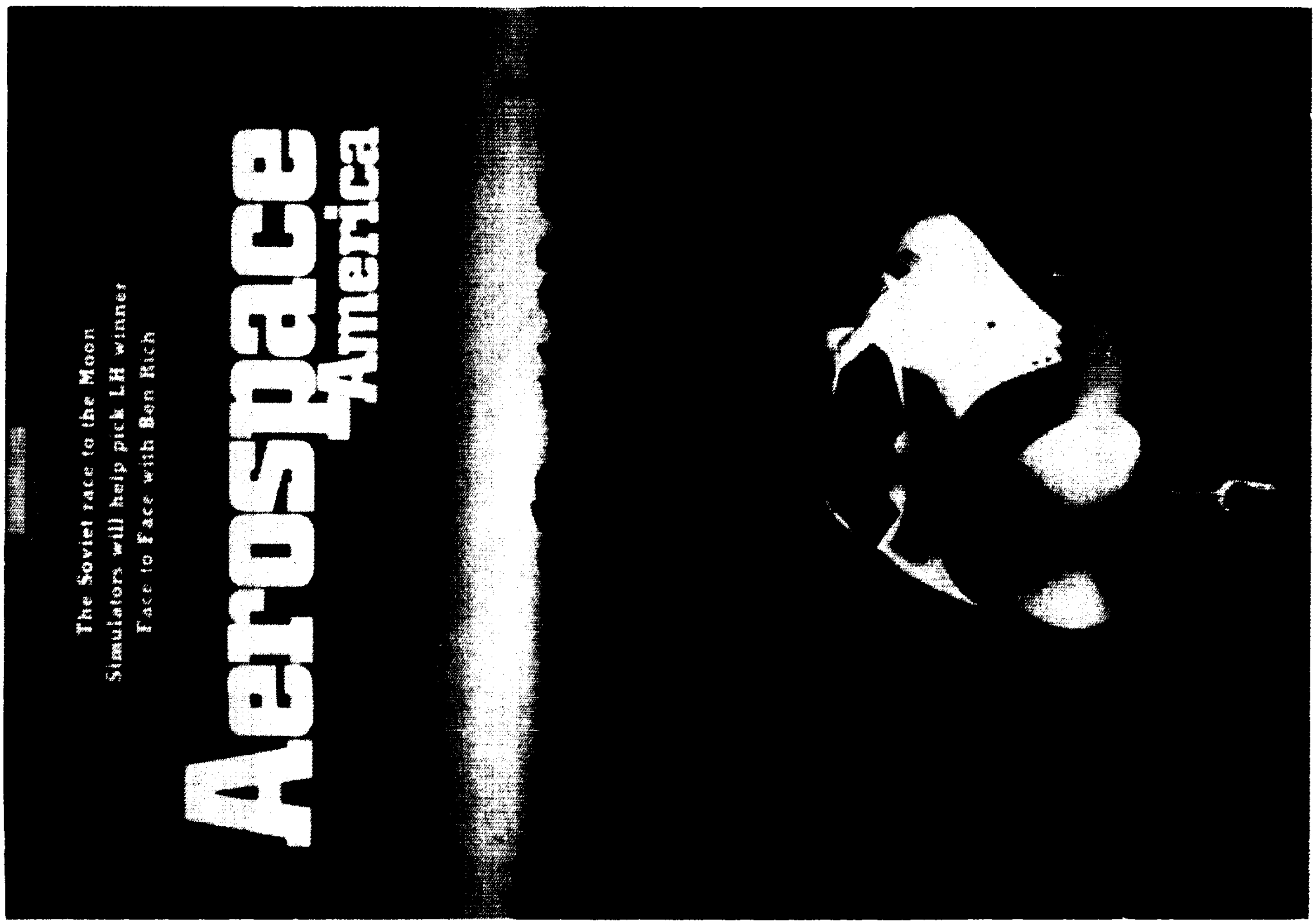
- DISCIPLINE RESEARCH
- UNIVERSITY PROGRAMS
- SPACE FLIGHT RESEARCH & TECHNOLOGY
- SYSTEMS ANALYSIS

Office of Aeronautics and Space Technology

PERSONNEL LAUNCH SYSTEM (PLS) BENCHMARK STUDY

NASA — LaRC — OAST — RS

SHOWN	● HL-20 LIFTING BODY PLS MOCKUP
OBJECTIVE	● TO ESTABLISH TECHNICALLY & OPERATIONALLY CREDIBLE MANNED EARTH-TO-ORBIT VEHICLE OPTION (PLS) AS A COMPLEMENT TO THE SPACE SHUTTLE
ACCOMPLISHMENT	● COMPLETED HL-20 BASELINE CONCEPT DEFINITION - DEVELOPED OPTIMUM CONFIGURATION - VALIDATED PERFORMANCE PARAMETERS - DEFINED DEVELOPMENT RISKS, PRODUCIBILITY, AND OPERABILITY - DETERMINED DEVELOPMENT COSTS AND RECURRING COSTS
BENEFITS	● ESTABLISHES TECHNICAL/OPERATIONAL VIABILITY OF HL-20 PLS ● ESTABLISHES A LOW DEVELOPMENT RISK OPTION FOR MANNED TRANSPORTATION
APPLICABLE MISSIONS	● SPACE STATION FREEDOM PERSONNEL TRANSPORTATION ● SMALL PAYLOAD DELIVERY AND RETURN ● EARTH OBSERVATIONS ● SATELLITE INSPECTION AND SERVICING



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OPTIMIZED PERSONNEL LAUNCH SYSTEM HL-20 DATABASE

NASA — LaRC — OAST

RF

SHOWN

- HL-20 LIFTING BODY WIND TUNNEL MODEL

OBJECTIVE

- TO EXPERIMENTALLY DETERMINE AERODYNAMIC/AEROTHERMODYNAMIC PERFORMANCE CHARACTERISTICS OF HL-20 LIFTING BODY CONFIGURATION AT HYPERSONIC TO SUBSONIC SPEEDS
- TO EVOLVE OPTIMUM AERODYNAMIC CONFIGURATION

ACCOMPLISHMENT

- DEVELOPED DATABASE TO DETERMINE PERFORMANCE CHARACTERISTICS
  - 5' MODEL TESTED AT SUBSONIC SPEEDS (MACH .1)
  - 20" MODEL TESTED AT TRANSONIC AND SUPERSONIC SPEEDS (MACH .3 TO 4.6)
  - 6' MODEL TESTED AT HYPERSONIC SPEEDS (MACH 6 AND 10)
- PROJECTED HL-20 PERFORMANCE IMPROVEMENTS
- EVOLVED OPTIMUM AERODYNAMIC CONFIGURATION
  - DETERMINED STATIC LONGITUDINAL/LATERAL DIRECTIONAL STABILITY, CONTROL AUTHORITY REQUIREMENTS, AND MAXIMUM LIFT-TO-DRAG AT VEHICLE LONGITUDINAL TRIM CONDITIONS

BENEFITS

- ESTABLISHES TECHNICAL VIABILITY OF LIFTING BODIES FOR APPLICATIONS IN SPACE TRANSPORTATION SYSTEMS

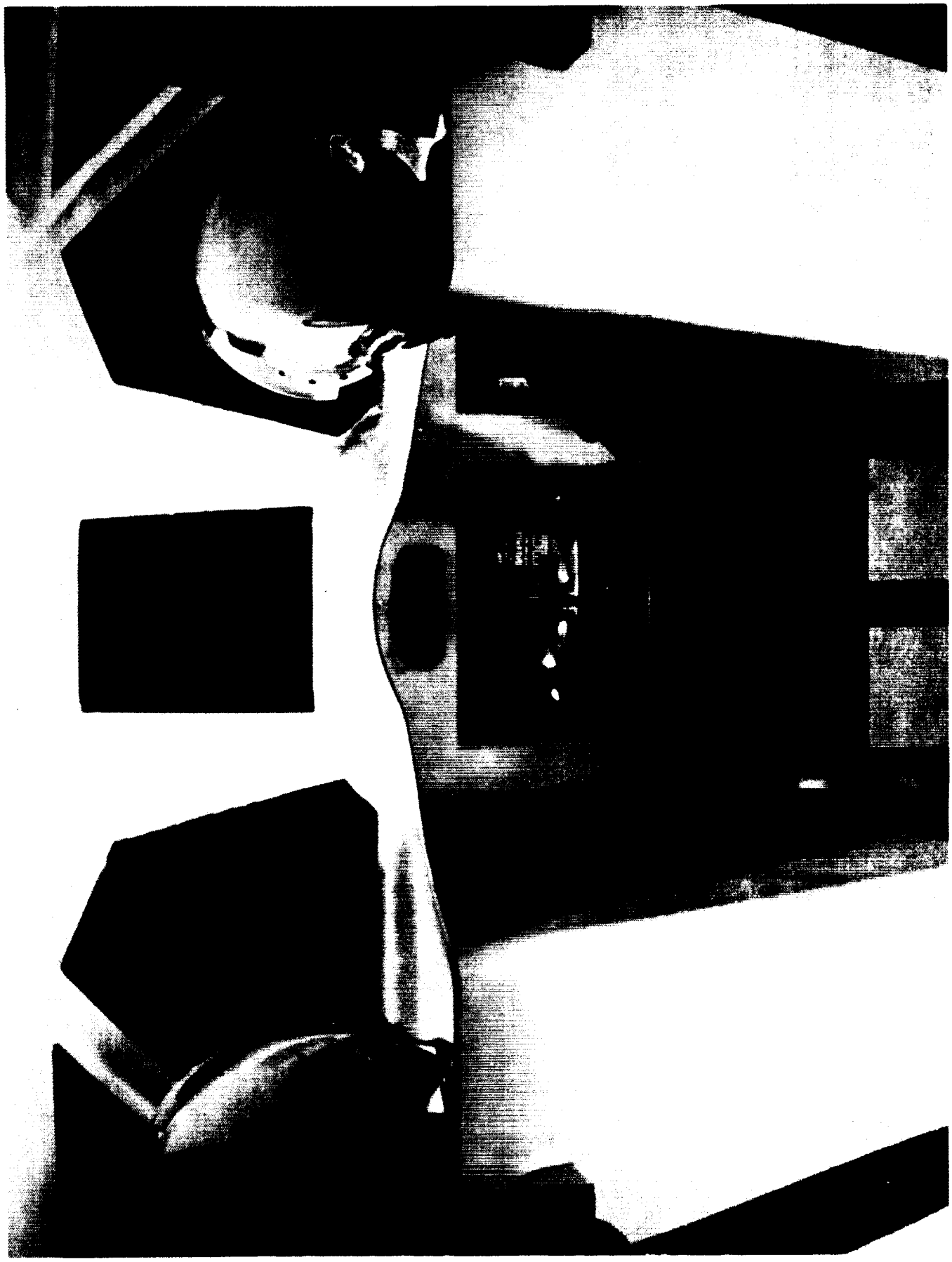
APPLICABLE MISSIONS

- SPACE STATION FREEDOM PERSONNEL TRANSPORTATION
- SMALL PAYLOAD DELIVERY AND RETURN
- EARTH OBSERVATIONS
- SATELLITE INSPECTION AND SERVICING

PERSONNEL LAUNCH SYSTEM (PLS) APPROACH & LANDING SIMULATION STUDY

NASA — LaRC — OAST — RC

SHOWN	● HL-20 LIFTING BODY PLS COCKPIT
OBJECTIVE	● TO ESTABLISH HL-20 LOW SPEED FLYING QUALITY RATINGS FOR MANUAL AND AUTOMATIC APPROACH & LANDING ON RUNWAYS UNDER A VARIETY OF NOMINAL AND OFF-NOMINAL CONDITIONS
ACCOMPLISHMENT	● ESTABLISHED HL-20 LOW SPEED FLYING QUALITY RATINGS OF LEVEL 1 (GOOD) - PILOTS AND ASTRONAUTS FLEW SIMULATED MANUAL HL-20 APPROACH AND LANDINGS UNDER SEVERAL NOMINAL AND ADVERSE CONDITIONS - DEMONSTRATED SIMULATED AUTOMATIC LANDINGS
BENEFITS	● ESTABLISHES TECHNICAL VIABILITY OF HL-20 PLS FOR BOTH MANUAL AND AUTOMATIC LANDINGS
APPLICABLE MISSIONS	● SPACE STATION FREEDOM PERSONNEL TRANSPORTATION ● SMALL PAYLOAD DELIVERY AND RETURN ● EARTH OBSERVATIONS ● SATELLITE INSPECTION AND SERVICING



CERAMIC MATRIX COMPOSITES

NASA — ARC — OAST

RF

SHOWN
- REINFORCED SILICON CARBIDE COMPOSITE MATERIAL FOR BUILDING THERMALLY PROTECTED SPACECRAFT STRUCTURES

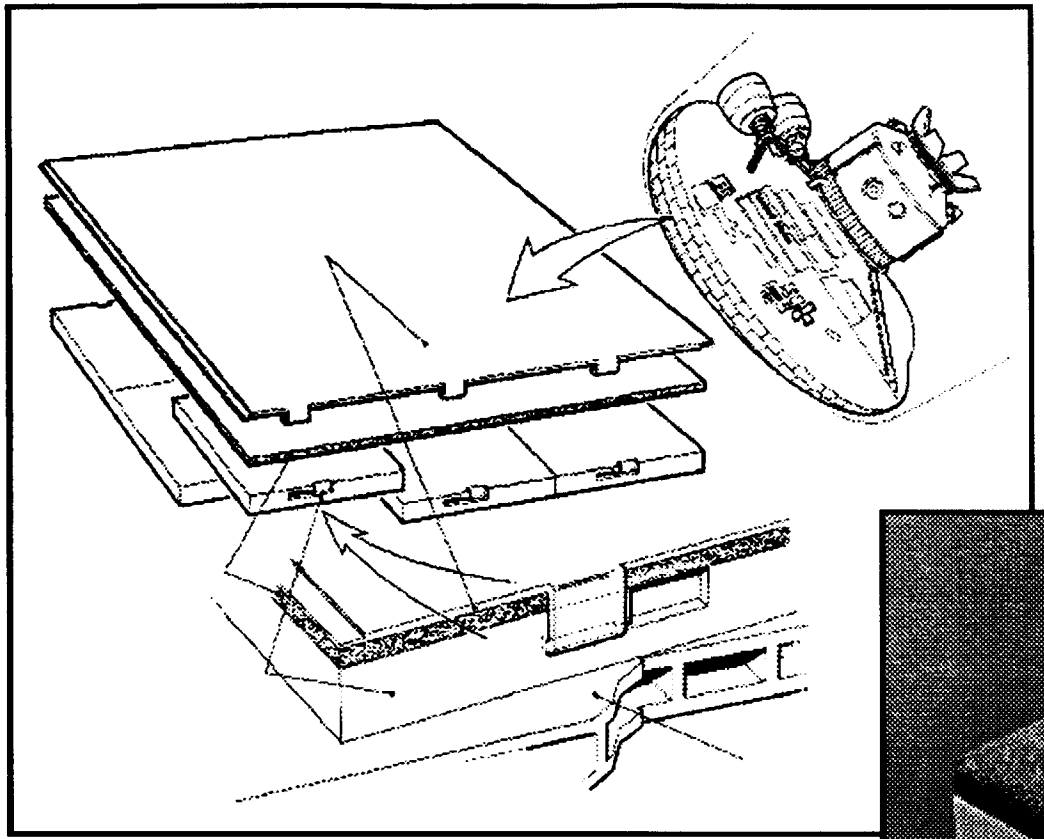
OBJECTIVE
- TO TEST CERAMIC MATRIX COMPOSITE MATERIALS THAT COMBINE HIGH STRENGTH AND TEMPERATURE RESISTANCE IN ORDER TO INTEGRATE INTERNAL VEHICLE STRUCTURE WITH ITS THERMAL PROTECTION SYSTEM
- TO DEVELOP AND TEST COMMERCIAL FABRICATION METHODS FOR THIS INTEGRATED STRUCTURE

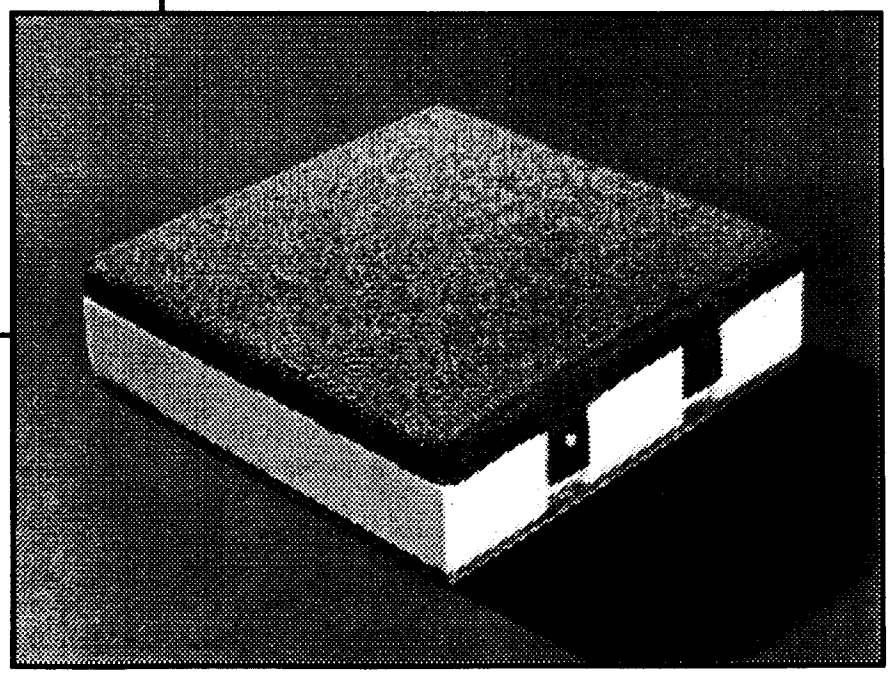
ACCOMPLISHMENT
- COMPLETED PHYSICAL PROPERTY TESTING OF CERAMIC MATRIX COMPOSITES SUBJECTED TO HIGH TEMPERATURE ATMOSPHERIC REENTRY CONDITIONS
- DEVELOPED A PROTOTYPE COMMERCIAL FABRICATION METHOD FOR THE INTEGRATED STRUCTURE

BENEFITS
- 50% REDUCTION IN VEHICLE STRUCTURE WEIGHT
  - ENABLES INCREASED PAYLOAD POTENTIAL OR REDUCED MISSION WEIGHT
- INCREASE IN RESISTANCE TO ADVERSE FLIGHT ENVIRONMENTS
  - REDUCES VEHICLE MAINTENANCE AND LIFE CYCLE COSTS

APPLICABLE MISSIONS
- NASP
- AEROBRAKE HOT STRUCTURES

TOP HAT
Thermal Protection System





WIND TUNNEL AIR FLOW DENSITY MEASUREMENTS USING HOLOGRAPHIC INTERFEROMETRY

NASA — ARC — OAST

RF

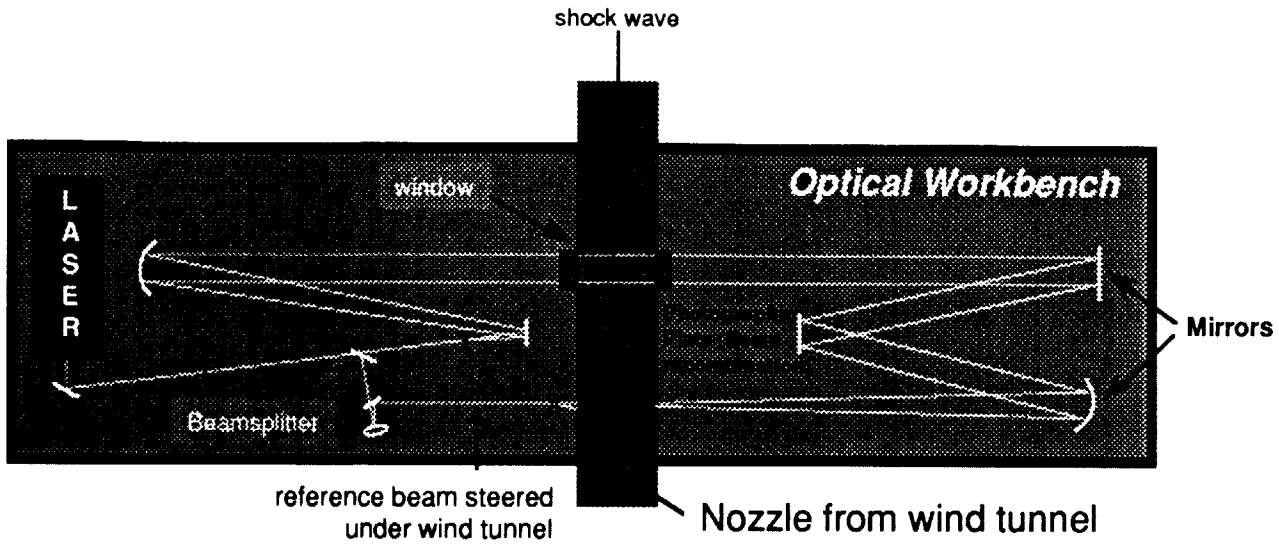
SHOWN
- INTERFEROMETRIC HOLOGRAMS OF THE AIR FLOW DENSITY THROUGH THE NOZZLE OF THE AMES ELECTRIC ARC DRIVE SHOCK TUNNEL (EAST), A WIND TUNNEL

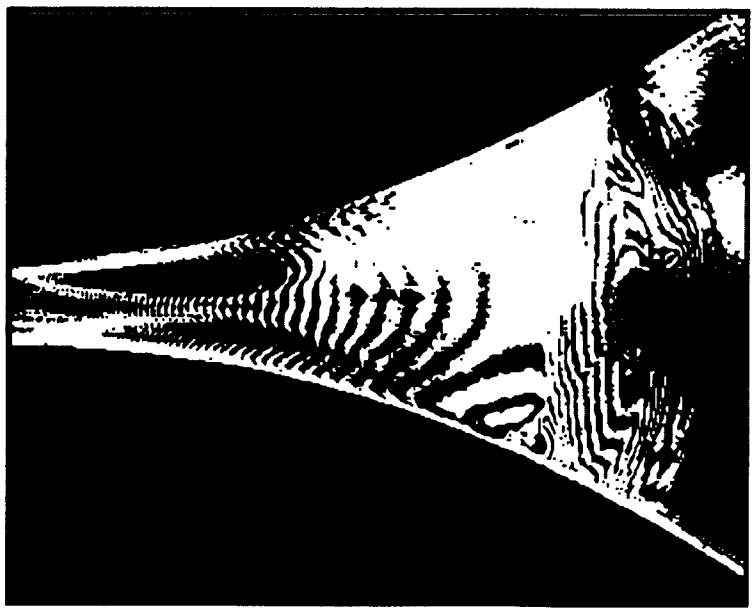
OBJECTIVE
- TO MEASURE THE AIR FLOW DENSITY IN THE NOZZLE OF THE EAST FACILITY USING HOLOGRAPHIC INTERFEROMETRY TECHNIQUES

ACCOMPLISHMENT
- CONVERTED ELECTRIC ARC DRIVEN SHOCK TUBE FACILITY TO A SHOCK TUNNEL BY ADDING A NOZZLE
- COMPLETED AIR FLOW DENSITY MEASUREMENTS THROUGH THE EAST NOZZLE USING HOLOGRAPHIC INTERFEROMETRY

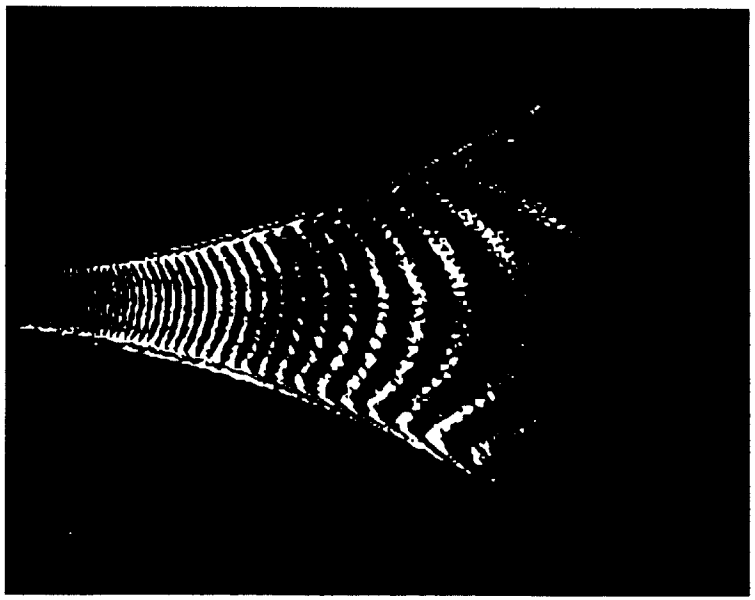
BENEFITS
- ENABLED FIRST GROUND-BASED TESTS OF WAKE FLOWS BEHIND A HYPERSONIC VEHICLE AT REALISTIC FLIGHT CONDITIONS

APPLICABLE MISSIONS
- NASP
- AEROBRAKE MISSIONS





Hologram taken after 9 μsec of the shock arrival



Hologram taken after 40 μsec of the shock arrival

MAGELLAN AEROBRAKE MANEUVER GAS FLOW PREDICTIONS

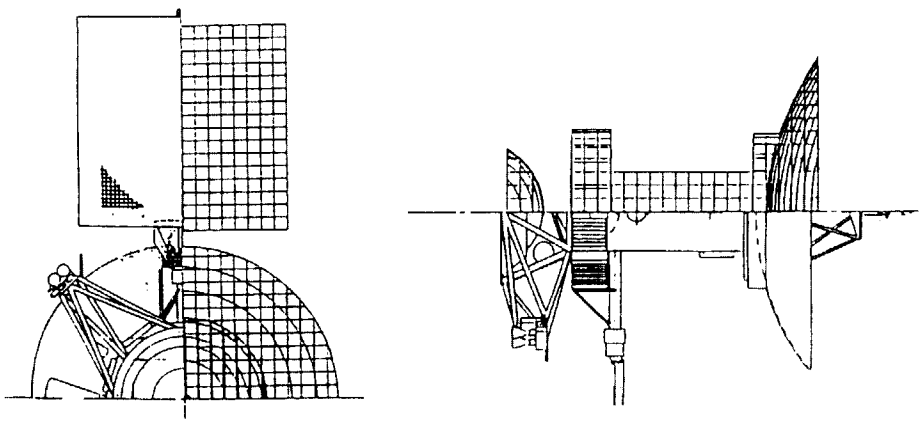
NASA — ARC — OAST

RF

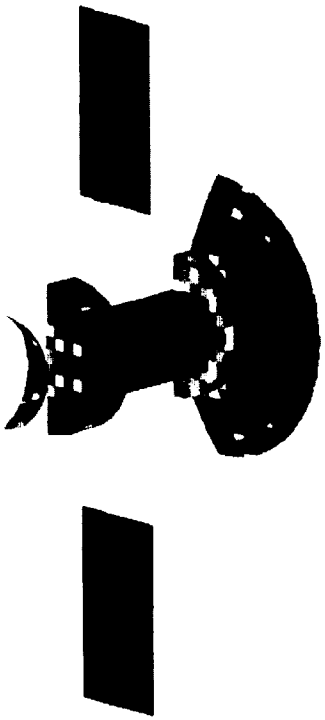
SHOWN	● TEMPERATURES IN THE FLOW FIELD ABOUT THE MAGELLAN SPACECRAFT DURING THE PROPOSED AEROBRAKE MANEUVER THROUGH THE ATMOSPHERE OF VENUS
OBJECTIVE	● TO MAKE AEROBRAKE MANEUVER GAS FLOW PREDICTIONS ABOUT THE MAGELLAN SPACECRAFT IN ORDER TO SELECT A HEAT-MINIMIZING TRAJECTORY THROUGH THE VENUS ATMOSPHERE (MANEUVER WILL CIRCULARIZE THE SPACECRAFT ORBIT TO PROVIDE ENHANCED RADAR IMAGING RESOLUTION)
ACCOMPLISHMENT	● PERFORMED RAREFIED FLOW CALCULATIONS TO DEFINE A HEAT-MINIMIZING MISSION TRAJECTORY FOR MAGELLAN THROUGH THE ATMOSPHERE OF VENUS
BENEFITS	● ENABLES HEAT-MINIMIZING TRAJECTORY PROJECTIONS FOR THE MAGELLAN SPACECRAFT (WHICH IS NOT PROTECTED FROM HIGH ATMOSPHERIC ENTRY TEMPERATURES) - ENSURES SPACECRAFT SURVIVABILITY DURING PROPOSED AEROBRAKE MANEUVER
APPLICABLE MISSIONS	● MAGELLAN

Particle Simulation Code
Application to Magellan Spacecraft Aerobraking

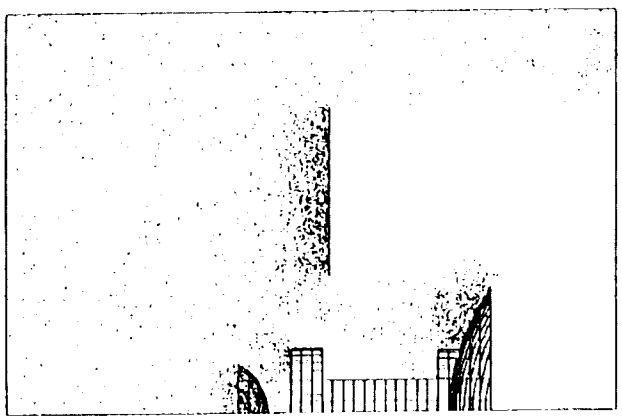
Simulation Geometry



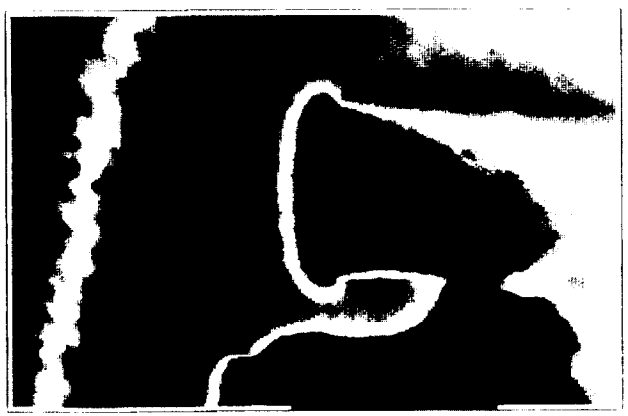
Surface Temperature Profile



Flowfield Particle Profile



Flowfield Temperature



ADVANCED CONCENTRATOR PHOTOVOLTAIC SYSTEM

NASA — LeRC — OAST

RP

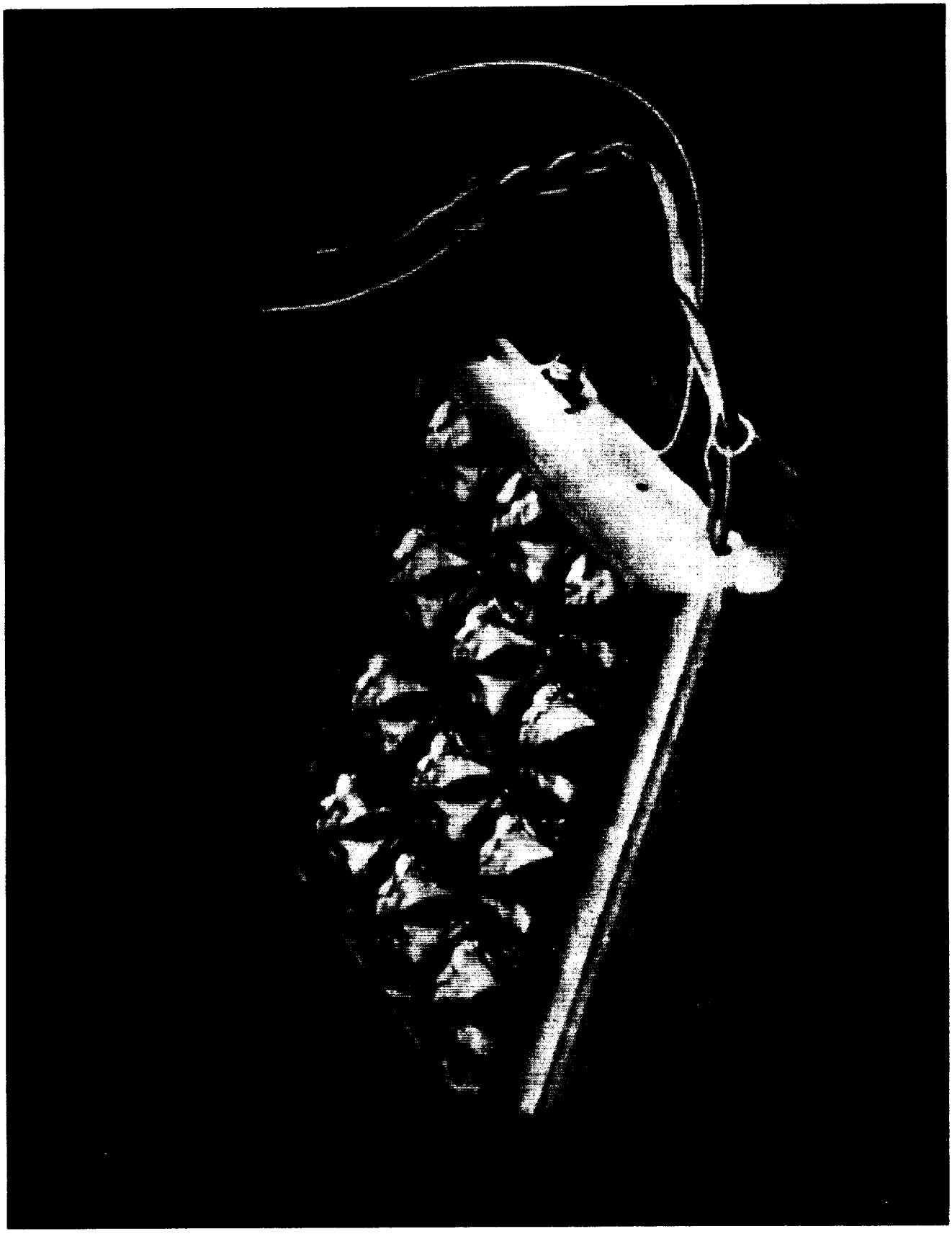
SHOWN
- 12-ELEMENT FLIGHT MODULE CONTAINING MINI-DOME FRESNEL LENS CONCENTRATORS TO BE FLOWN ON PLASMA EXPERIMENT (PEGASUS LAUNCH, NOVEMBER 1992)

OBJECTIVE
- TO DEVELOP LOW-COST SOLAR POWER SYSTEMS WITH REDUCED AREA (HIGH POWER PER UNIT AREA) AND LIGHT WEIGHT (HIGH POWER PER UNIT MASS)

ACCOMPLISHMENT
- DEVELOPED PROTOTYPE SUBMODULE AND DEMONSTRATED >300 W/SQ.M (3X INCREASE OVER SPACE STATION FREEDOM ARRAY POWER PER UNIT AREA)
- DEVELOPED PRELIMINARY PANEL DESIGN USING MINI-DOME FRESNEL LENS CONCENTRATORS WITH 95 W/KG (2X INCREASE OVER STATE-OF-THE-ART RIGID PANEL POWER PER UNIT MASS)

BENEFITS
- ENABLES LOW COST, SMALL AREA (LOW DRAG), HIGH POWER SPACE-BASED SOLAR POWER SOURCE

APPLICABLE MISSIONS
- SPACE STATION FREEDOM
- SPACE PLATFORMS
- ORBIT TRANSFER (HOUSEKEEPING OR SOLAR ELECTRIC PROPULSION)
- HIGH POWER COMMUNICATIONS SATELLITES



HIGH CYCLE LIFE RECHARGEABLE LITHIUM BATTERY

NASA — JPL — OAST

RP

SHOWN
- RECHARGEABLE LITHIUM BATTERY TEST CELL

OBJECTIVE
- DEVELOP RECHARGEABLE LITHIUM BATTERY WITH SPECIFIC ENERGY OF 100 W-h/kg AT CELL LEVEL WITH LIFETIME OF 1000 CYCLES AT 50% DEPTH OF DISCHARGE

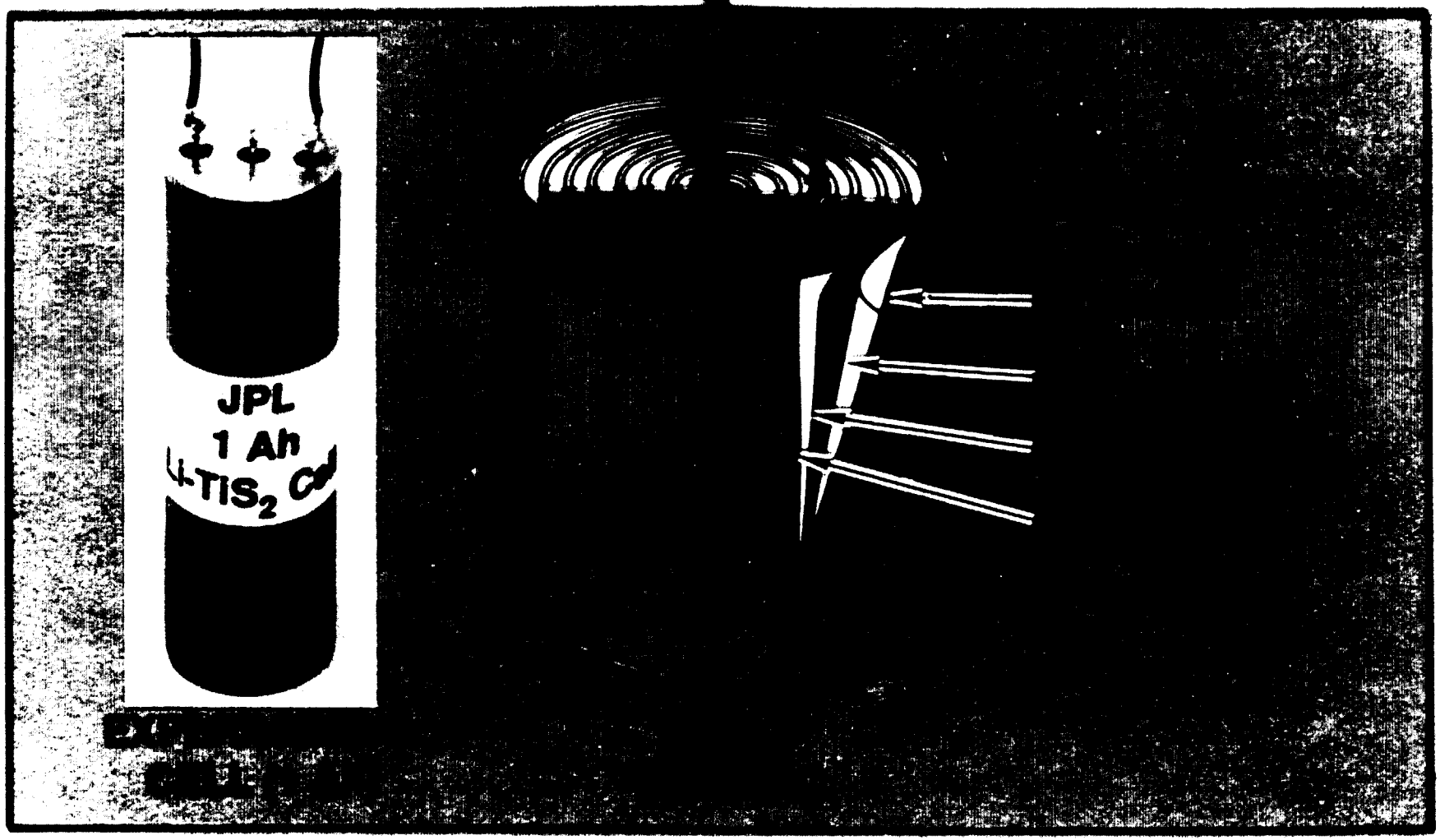
ACCOMPLISHMENT
- ACHIEVED (IN-HOUSE) FOR THE FIRST TIME OVER 750 CYCLES AT 50% DEPTH OF DISCHARGE IN LABORATORY TEST CELLS
- DEVELOPED (CONTRACTOR) 'AA' CELL WITH 120 W-h/kg. CELL TESTED TO OVER 900 CYCLES AT 50% DEPTH OF DISCHARGE.

BENEFITS
- DEMONSTRATES FEASIBILITY OF HIGH ENERGY DENSITY RECHARGEABLE LITHIUM BATTERIES
- 3X SPECIFIC ENERGY OF STATE-OF-THE-ART NICKEL HYDROGEN BATTERIES
- MISSION IMPACT:
  - 2X REDUCTION IN WEIGHT
  - 2X INCREASE IN MISSION CAPABILITY USING SAME BATTERY
  - 1/3 REDUCTION IN VOLUME

APPLICABLE MISSIONS
- EARTH ORBITAL SPACECRAFT
- ROBOTIC PLANETARY SPACECRAFT
- PLANETARY ROVERS

JPL RECHARGEABLE LITHIUM BATTERY TECHNOLOGY

LI-TIS_2 CELL



ORIGINAL PAGE
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NASCAP/LEO SSF DESIGN IMPROVEMENTS

NASA — LeRC — OAST

RP

SHOWN
- SAMPLE CALCULATIONS OF ELECTRICAL POTENTIALS AROUND SPACE STATION FREEDOM (SSF) USING NASA CHARGING ANALYSIS PROGRAM FOR LOW EARTH ORBIT (NASCAP/LEO)

OBJECTIVE
- TO DEVELOP 3D COMPUTER MODELLING TECHNIQUES FOR PREDICTING SPACECRAFT ELECTRICAL INTERACTIONS (e.g. GROUND POTENTIAL, PARASITIC CURRENTS, ELECTRICAL SPUTTERING AND ARCING) WITH THE LEO ENVIRONMENT

ACCOMPLISHMENT
- DEVELOPED NASCAP/LEO (3D COMPUTER MODELLING)
- APPLIED MODEL TO SPACE STATION FREEDOM
  - VERIFIED NEED FOR SPACE PLASMA GROUNDING DEVICE TO PREVENT ARCING AND SPUTTERING
  - SSF PROGRAM OFFICE IMPROVED SPACECRAFT DESIGN CHANGE

BENEFITS
- ENABLES PREDICTIONS OF COMPLEX ELECTRICAL INTERACTIONS WITH THE SPACE ENVIRONMENT
  - REDUCES RISK OF ELECTRICAL ARCING AND SPUTTERING
  - IMPROVES SPACECRAFT RELIABILITY (REDUCES UPSETS BY >90%)
  - 3X INCREASE IN SPACECRAFT LIFETIME (FROM 5 YEARS TO >15 YEARS)

APPLICABLE MISSIONS
- SPACE STATION FREEDOM
- SPACE SHUTTLE MISSIONS
- LEO-ORBITING PLATFORMS (e.g. EOS, COLUMBUS)
- ALL LEO SPACECRAFT

NASA
C-90-03928

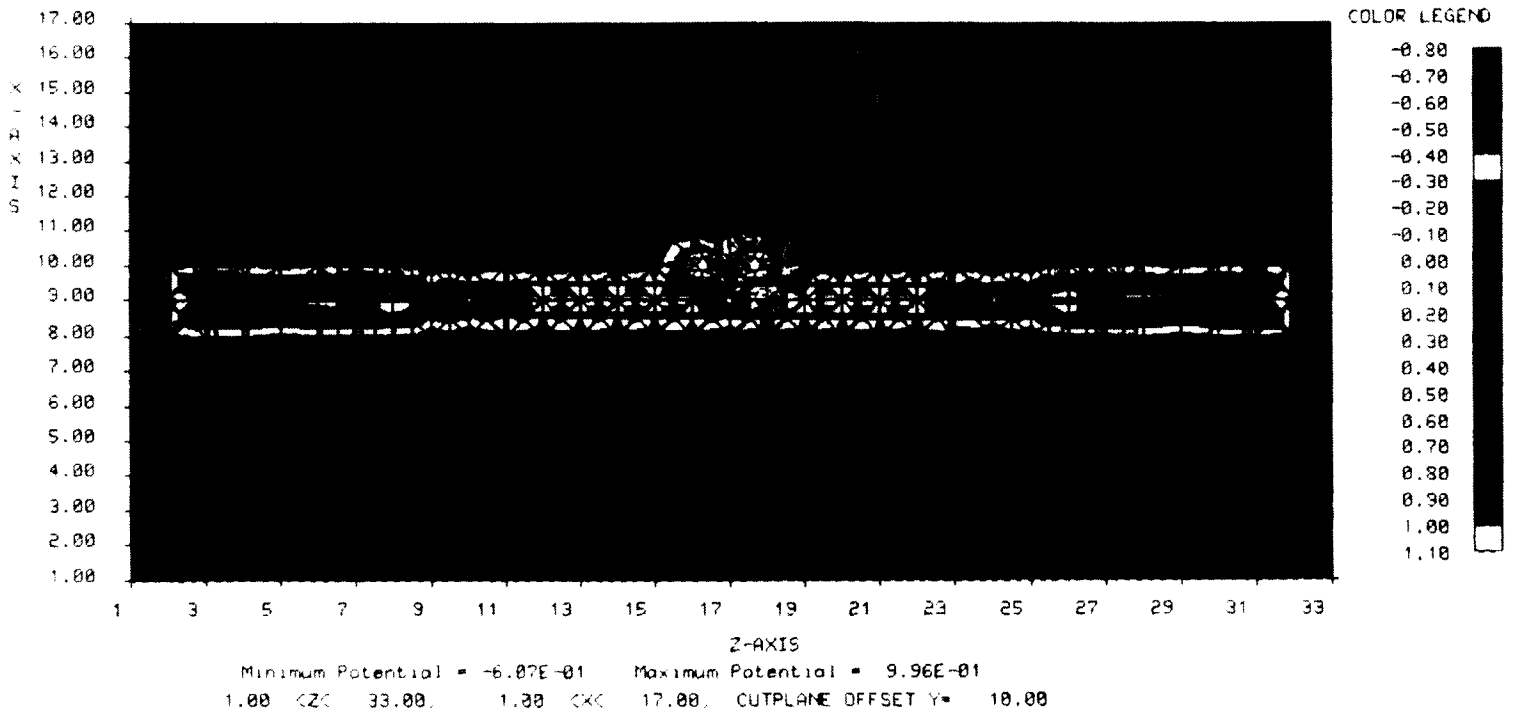
National Aeronautics and
Space Administration
Lewis Research Center

SPACE ENVIRONMENT EFFECTS BRANCH

NASA

NASCAP/LEO VALIDATION STUDIES

SPACE STATION FREEDOM



NASCAP/LEO – S-CUBED
SIMULATION – J. HERR, SVERDRUP TECHNOLOGY

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BLACK AND WHITE PHOTOGRAPH

ADVANCED PHOTOVOLTAIC SOLAR ARRAY (APSA)

NASA — JPL — OAST

RP

SHOWN	● STOWED APSA ARRAY MOUNTED ON VIBRATION FIXTURE FOR GROUND TESTING
OBJECTIVE	● TO DEVELOP ULTRA LIGHT WEIGHT SOLAR ARRAYS WITH A 10 FOLD IMPROVEMENT IN SPECIFIC POWER (W/KG)
ACCOMPLISHMENT	● DEMONSTRATED VIA VIBROACOUSTIC GROUND TESTING THAT AN ULTRA LIGHT WEIGHT (140 W/KG) SOLAR ARRAY DESIGN CAN SURVIVE A LAUNCH
BENEFITS	● 3-5X IMPROVEMENT IN SPECIFIC POWER OVER CURRENT RIGID-PANEL ARRAYS (HIGHER POWER ENABLES LOWER MASS) ● ENABLES DOUBLING OF MAXIMUM MISSION DISTANCE FROM SUN FROM 1.6 TO 3.2 AU
APPLICABLE MISSIONS	● LEO/GEO COMMERCIAL MISSIONS ● LEO/GEO/INTERPLANETARY SCIENTIFIC MISSIONS ● EOS POLAR PLATFORM ● DOD MISSIONS

HOT ROCKET TECHNOLOGY

NASA LeRC OAST

RP

SHOWN

- 14 LB FORCE, STORABLE PROPELLANT (NITROGEN TETROXIDE/MONOMETHYL HYDRAZINE) THRUSTERS. ON LEFT: NEW HIGH TEMPERATURE IRIDIUM-COATED RHENIUM CHAMBER. ON RIGHT: STATE-OF-THE-ART (SOA) SILICIDE-COATED COLUMBIUM CHAMBER

OBJECTIVE

- TO DEMONSTRATE REVOLUTIONARY PERFORMANCE IMPROVEMENT (SPECIFIC IMPULSE & CONTAMINATION) FOR STORABLE PROPELLANT PROPULSION SYSTEMS

ACCOMPLISHMENT

- DEMONSTRATED FABRICATION TECHNOLOGIES FOR ULTRA-HIGH TEMPERATURE MATERIALS (800°C ABOVE SOA)
  - OBTAINED SIGNIFICANT (6%) PERFORMANCE IMPROVEMENT OVER SOA
  - FILM COOLING (A MAJOR CONTAMINATION SOURCE) ELIMINATED

BENEFITS

- INCREASED PERFORMANCE PROVIDES 1 YEAR LIFE EXTENSION FOR A SPECIFIC DOD MISSION
- ELIMINATION OF FILM COOLING REDUCES SPACECRAFT CONTAMINATION

APPLICABLE MISSIONS

- STATIONKEEPING, DRAG MAKEUP, APOGEE , OR REACTION CONTROL PROPULSION FOR COMMERCIAL/DOD/NASA SATELLITES

HIGH POWER ELECTRIC PROPULSION

NASA LeRC — OAST

RP

SHOWN	● A MAGNETOPLASMADYNAMIC THRUSTER (MPDT) OPERATING AT OVER 200 KW
OBJECTIVE	● TO DEMONSTRATE MPDT OPERATION AT POWER LEVELS REQUIRED FOR SPACE EXPLORATION INITIATIVE (SEI) PRECURSOR, AND SEI CARGO AND PILOTED MISSIONS
ACCOMPLISHMENT	● CONSTRUCTED HIGH POWER (350 KW) MPDT TEST STAND ● DEMONSTRATED INCREASED MPDT POWER LEVELS (FROM 30 KW TO OVER 200 KW) AT SPECIFIC IMPULSES TO APPROXIMATELY 3700 SECONDS ● DEMONSTRATED 2X INCREASE IN THRUST EFFICIENCY
BENEFITS	● PROVIDES SIMPLE, ROBUST THRUSTER CANDIDATE FOR HIGH POWER ELECTRIC PROPULSION APPLICATIONS
APPLICABLE MISSIONS	● SEI PRECURSOR MISSIONS ● CARGO AND PLANETARY MISSIONS

FOIL BEARING TECHNOLOGY

NASA – LeRC — OAST

RP

SHOWN
- TYPICAL FOIL BEARING CONFIGURATION

OBJECTIVE
- TO DEVELOP ADVANCED CRYOGENIC FOIL BEARING TECHNOLOGY TO PROVIDE LONG LIFE, HIGH LOAD CAPACITY, AND GOOD STABILITY

ACCOMPLISHMENT
- TESTED FOIL BEARINGS UNDER WIDE RANGE OF CONDITIONS ANTICIPATED IN APPLICATION
  - PERFORMED 150 START-STOP CYCLES WITH NO NOTICEABLE WEAR
  - DEMONSTRATED STABILITY AT ALL SPEEDS (10-97,000 RPM)
  - ACHIEVED 240 PSI LOAD CAPACITY IN LIQUID HYDROGEN AND 300 PSI LOAD CAPACITY IN LIQUID NITROGEN
- DEVELOPED COMPUTATIONAL FOIL BEARING ANALYSIS TOOL

BENEFITS
- ELIMINATE PUMP SPEED CONSTRAINTS ASSOCIATED WITH ROLLING ELEMENTS
- SIGNIFICANT INCREASES IN BEARING LIFE (POTENTIALLY UNLIMITED LIFE)
- COOLANT REQUIREMENTS SIGNIFICANTLY REDUCED
- IMPROVED BEARING DYNAMIC CHARACTERISTICS

APPLICABLE MISSIONS
- LUNAR MISSIONS
- INTERPLANETARY MISSIONS
- NASP
- EARTH-TO-ORBIT UPPERSTAGE PROPULSION
- LOX, HYDROGEN, AND HYDROCARBON TURBOPUMPS

PROPULSION FY91

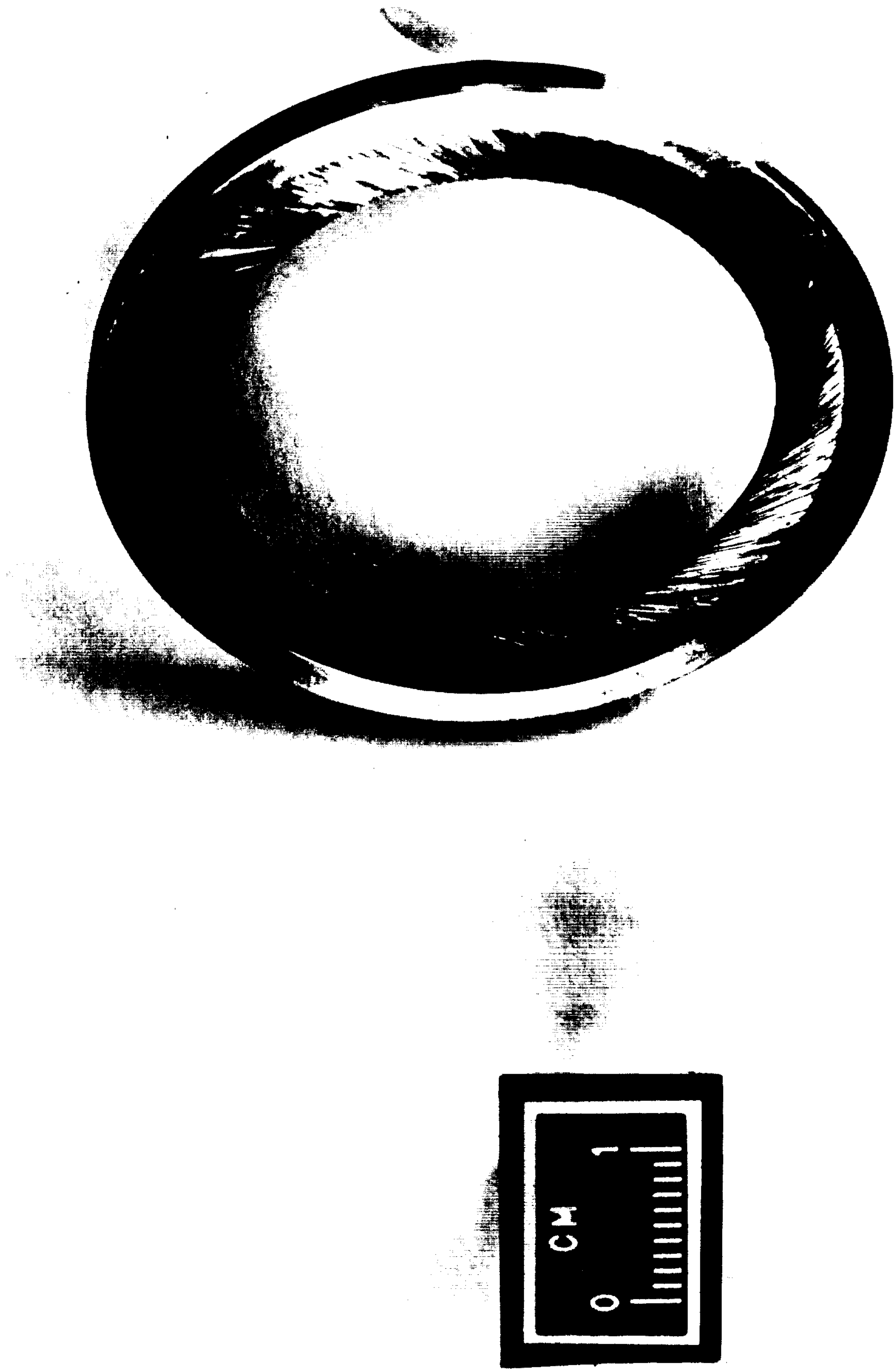
R&T BASE

BRUSH SEAL TECHNOLOGY

NASA LeRC — OAST

RP

SHOWN	● TYPICAL BRUSH SEAL CONFIGURATION
OBJECTIVE	● TO DEVELOP COMPLIANT, DYNAMICALLY STABLE, LONG LIFE, LOW LEAKAGE SEAL TECHNOLOGY FOR CRYOGENIC AND HOT GAS APPLICATIONS
ACCOMPLISHMENT	● DEVELOPED BRUSH SEAL TECHNOLOGY - VERIFIED SEAL AGAINST KNOWN LOW LEAKAGE RATES IN GAS MEDIUMS (STEAM, AIR, ARGON,GASEOUS NITROGEN, CARBON MONOXIDE, AND HELIUM) - DEMONSTRATED LOW LEAKAGE RATE IN FIRST TESTS IN CRYOGENIC FLUID (LIQUID NITROGEN)
BENEFITS	● 1/3 TO 1/2 REDUCTION IN LEAKAGE RATES COMPARED TO STATE-OF-THE-ART CONVENTIONAL LABYRINTH SEALS
APPLICABLE MISSIONS	● UPPER STAGE PROPULSION SYSTEMS, ELECTRIC POWER SYSTEMS ● EARTH-TO-ORBIT PROPULSION: SPACE TRANSPORTATION MAIN ENGINE



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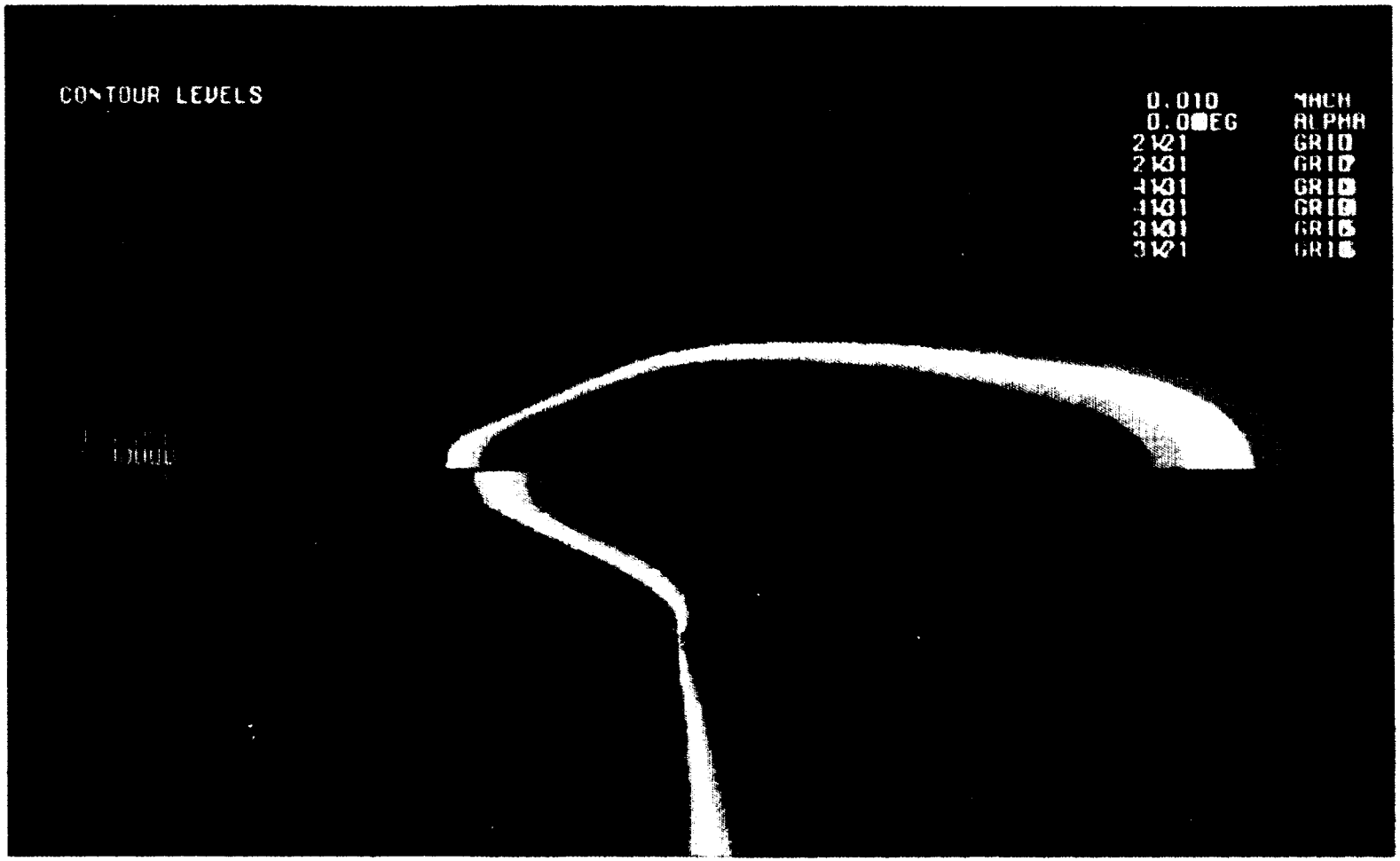
MOLECULAR COMPUTATIONAL FLUID DYNAMICS (MCFD)

NASA — LeRC — OAST

RP

SHOWN	● NUMERICAL SIMULATION OF SMALL THRUSTER PLUME EXPANSIONS INTO A PERFECT VACUUM (BOTTOM) AND A TYPICAL EXPERIMENTALLY OBTAINABLE VACUUM (TOP)
OBJECTIVE	● TO DEVELOP ACCURATE PREDICTIVE ANALYSIS TOOLS FOR VISCOUS NOZZLE FLOWS IN ORDER TO ASSESS SMALL THRUSTER PLUME IMPACTS (CONTAMINATION, THERMAL AND MOMENTUM TRANSFER, AND COMMUNICATIONS) AND TO ASSESS FACILITY EFFECTS ON PLUMES
ACCOMPLISHMENT	● DEVELOPED NUMERICAL CODES FOR ANALYSIS OF VISCOUS NOZZLE FLOWS ● DIRECTLY COMPARED NUMERICAL CODE RESULTS TO STATE-OF-THE-ART CONTINUUM CODE RESULTS AND TO LAB EXPERIMENTS ● EVALUATED FACILITY EFFECTS ON GROUND-BASED PLUME MEASUREMENTS
BENEFITS	● ENABLES ACCURATE PREDICTION OF SMALL THRUSTER PLUME FLOWS (UNAVAILABLE FROM SOA PLUME CODES OR GROUND BASED EXPERIMENTS)
APPLICABLE MISSIONS	● ON-BOARD PROPULSION

MACH CONTOURS: 2-D FINITE DIFFERENCE METHOD



Upper Half: Finite Ambient Pressure Lower Half: Perfect Vacuum

MOLECULAR CFD USED TO PREDICT FACILITY EFFECTS

TOUGHENED UNI-PIECE FIBROUS INSULATION (TUFI) THERMAL PROTECTION MATERIAL

NASA — ARC — OAST — RM

SHOWN

- IMPROVED DAMAGE RESISTANCE OF CURRENT THERMAL PROTECTION MATERIAL TECHNOLOGY

OBJECTIVE

- TO DEVELOP NEW THERMAL PROTECTION MATERIALS AND SYSTEMS FOR ADVANCED SPACECRAFT AND HYPERSONIC VEHICLES
- TO DEVELOP ADVANCED COMPUTER MODELING AND TESTING METHODS OF THERMAL PROTECTION SYSTEMS

ACCOMPLISHMENT

- DEVELOPED NEW THERMAL PROTECTION MATERIAL, TUFI, AND CERTIFIED MATERIAL DURING SIX SPACE SHUTTLE FLIGHTS
- DEVELOPED MODIFIED TUFI MATERIAL AND DEMONSTRATED MULTIPLE EXPOSURES (VIA ARCJET TESTS) AT 2900^{o}F

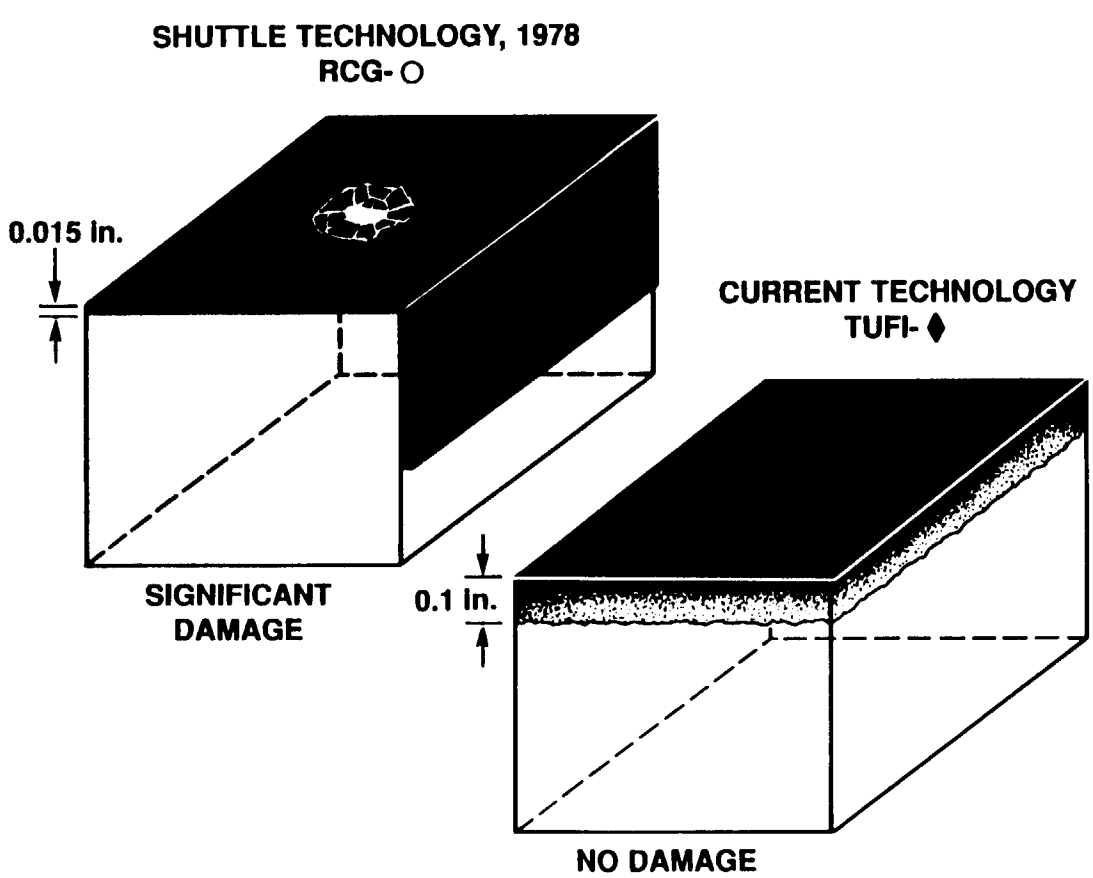
BENEFITS

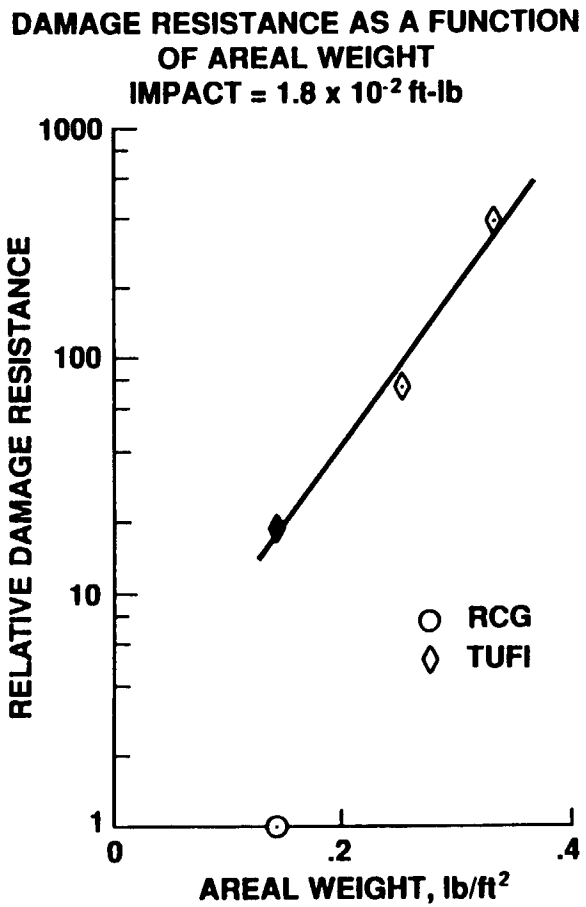
- 10 TO 1000 TIMES IMPROVED IMPACT RESISTANCE AS COMPARED TO STATE-OF-THE-ART BASELINE REACTION CURED GLASS (RCG) COATING
- ENABLES EASIER REWATERPROOFING COMPARED TO RCG COATING SYSTEM
- EASILY ADAPTS TO HEAT SHIELD MATERIALS WITH COMPLEX SHAPES (RCG TOO RIGID)

APPLICABLE MISSIONS

- SPACE SHUTTLE IN HIGH DAMAGE AREAS
- AEROBRAKES
- PLANETARY PROBES (MESUR, PV PRIME)
- DOD VEHICLES (ATF, B-2, SDIO/SSTO)
- HYPERSONIC VEHICLES (SWERVE, PEGASUS WING GLOVE)

IMPACT RESISTANCE OF RSI COATING SYSTEMS





ADAPTIVE UNSTRUCTURED MESHES

NASA = LaRC — OAST

RM

SHOWN

- COMPARISON OF ADAPTIVE (TOP) AND NONADAPTIVE (BOTTOM) MESH COMPUTATIONS ON A THERMALLY-LOADED STRUCTURE. GRAPH SHOWS ACCURACY OF MESH RESULTS COMPARED TO ACTUAL THERMAL LOAD. FOR NONADAPTIVE MESHING TO ACHIEVE SAME RESULTS AS ADAPTIVE MESHING, COMPUTER PROCESSING TIME IS INCREASED (FROM 300 TO 9400 SEC) AND MESH SIZE IS INCREASED (FROM 200 TO 5200 NODES)

OBJECTIVE

- TO DEVELOP AN ADAPTIVE MESHING TECHNIQUE FOR TRANSIENT THERMAL ANALYSIS OF STRUCTURES IN ORDER TO MORE ACCURATELY CALCULATE THE RESPONSE OF THE STRUCTURES TO TRANSIENT THERMAL LOADS

ACCOMPLISHMENT

- DEVELOPED ADAPTIVE MESHING ALGORITHM
- APPLIED ALGORITHM TO THERMAL ANALYSIS OF A STRUCTURE WITH A GIVEN THERMAL LOAD
  - DEMONSTRATED 10X IMPROVEMENT IN COMPUTATIONAL EFFICIENCY COMPARED TO STATE-OF-THE-ART NONADAPTIVE METHODS

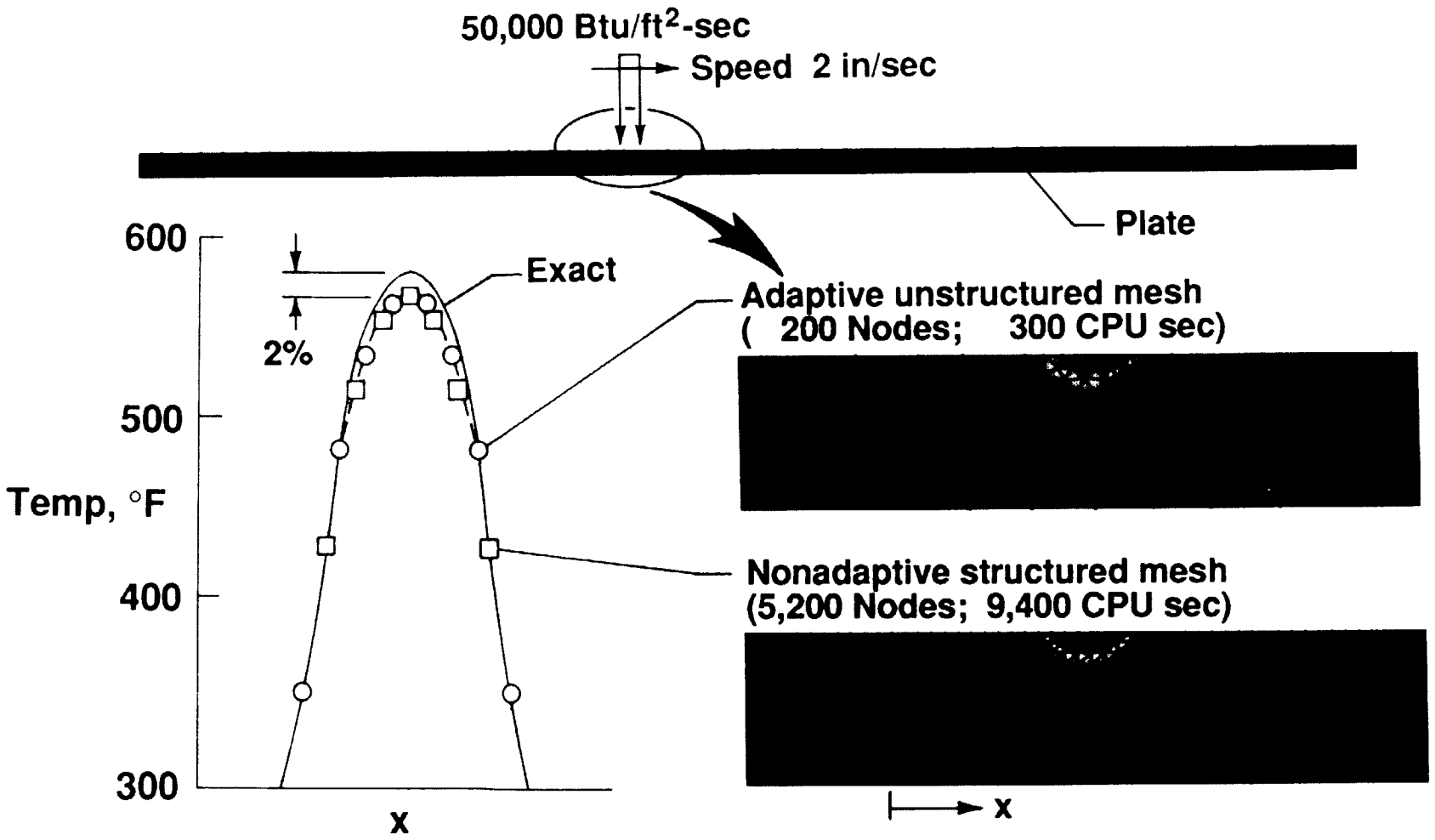
BENEFITS

- REQUIRES FEWER NUMBER OF COMPUTATIONAL CYCLES
  - REDUCES COMPUTATIONAL COSTS
  - SAVES ANALYST TIME
- ENABLES IMPROVED SOLUTIONS IN LESS TIME WITH SMALLER MESH SIZES

APPLICABLE MISSIONS

- NASP
- HYPERSONIC VEHICLES
- SPACE TRANSPORTATION SYSTEMS

TRANSIENT ADAPTIVE MESHING IMPROVES ACCURACY AND EFFICIENCY OF PLATE THERMAL ANALYSIS



Predicted temperatures within 2% of exact solution

Unstructured mesh order of magnitude more efficient

RADIATION RESISTANCE OF NOVEL TIN-CONTAINING POLYIMIDE

NASA — LaRC — OAST

RM

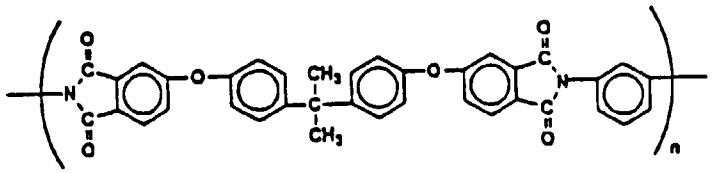
SHOWN
- TIN-CONTAINING POLYMIDE MATERIAL

OBJECTIVE
- TO IMPROVE ATOMIC OXYGEN RESISTANCE OF POLYMER MATERIALS IN THE SPACE ENVIRONMENT

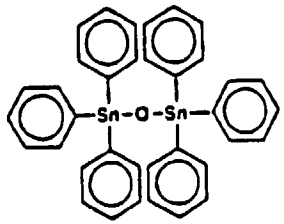
ACCOMPLISHMENT
- DEVELOPED THREE POLYMER MATERIAL SYSTEMS WITH Bis(TRIPHENYL TIN) OXIDE (BTO) MOLECULAR STRUCTURE(POLYETHERIMIDE, POLYSULFONE, AND POLYPYROMELLITIMIDE)
- TESTED MODIFIED POLYMER SYSTEMS AGAINST ATOMIC OXYGEN, ULTRAVIOLET , AND ELECTRON BOMBARDMENT
  - 40% DECREASE IN ATOMIC OXYGEN EROSION RATE
  - NO EFFECT ON POLYMER RESISTANCE TO ULTRAVIOLET AND ELECTRON BOMBARDMENT

BENEFITS
- ENABLES LONGER-LIFE, MORE DURABLE, BETTER PERFORMING SPACECRAFT MATERIALS
- ENABLES MULTIPLE PRODUCT FORMS (FILM, COATING, THICK CASTING, ADHESIVE, OR MATRIX RESIN)

APPLICABLE MISSIONS
- LONG DURATION LOW EARTH ORBIT PLATFORMS AND SATELLITES
- SPACE STATION FREEDOM
- EARTH-RESOURCE-MONITORING PLATFORMS
- LONG DURATION SCIENCE MISSIONS
- DEPLOYABLE STRUCTURES



REPEAT UNIT OF THE POLYETHERIMIDE



BTO

Fig. 1

COMPARISON OF RATES OF EROSION IN ATOMIC OXYGEN

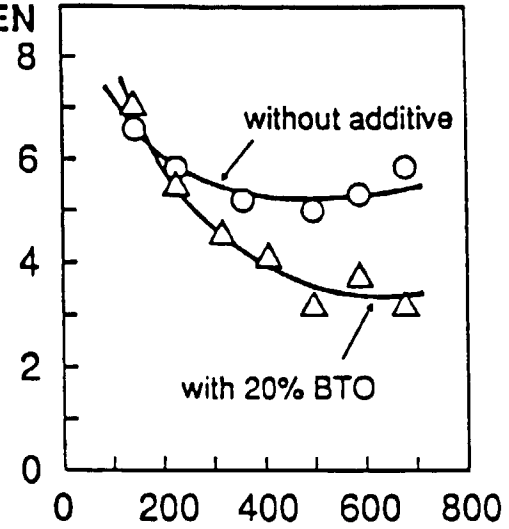


Fig. 2

EXPOSURES OF POLYETHERIMIDE / BTO FILMS

(10% BTO)

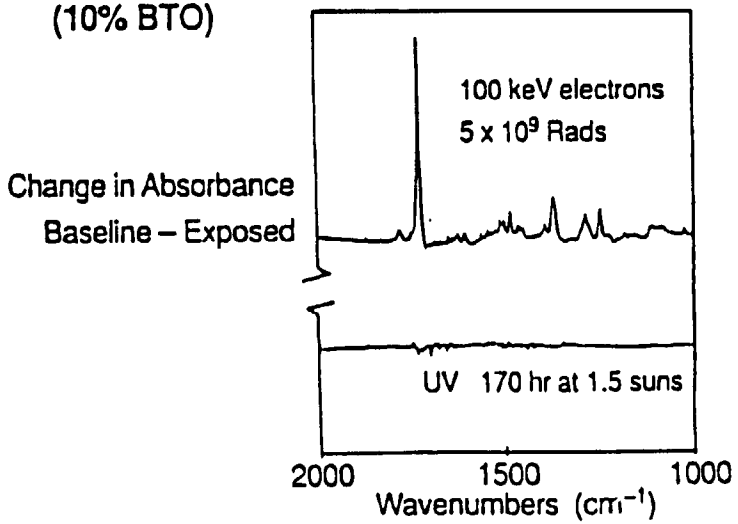


Fig. 3

- BTO reduces atomic oxygen erosion of polyetherimide by a third.
- Pure polyetherimide and polyetherimide/BTO lose C=O with electron exposure.
- Pure polyetherimide and polyetherimide/BTO show no chemical change with UV exposure.

LONG DURATION EXPOSURE FACILITY (LDEF) SUMMARY

METEOROIDS & DEBRIS (M&D):

- CURRENT M & D ENVIRONMENT MODELS INACCURATE
  - SMALL PARTICLE IMPACT FLUX OVERESTIMATED
  - LARGE PARTICLE IMPACT FLUX UNDERESTIMATED
  - M&D IMPACTS ARE NOT RANDOM IN TIME AND ARE DIRECTIONALLY ANISOTROPIC (NON-UNIFORM)
- DETECTED BETA METEOROIDS (SMALL PARTICLES FROM SOLAR DIRECTION) ON SPACECRAFT

IONIZING RADIATION:

- CURRENT ISOTROPIC MODEL FOR TRAPPED PROTONS IN SOUTH ATLANTIC MAGNETIC FIELD ANOMALY IS IN ERROR BY A FACTOR OF THREE
- DISCOVERY OF RADIOACTIVE 7Be ON ALL LDEF FRONT SURFACES (10-1000X HIGHER CONCENTRATION OF COSMIC RADIATION BY-PRODUCT IN UPPER ATMOSPHERE THAN EXPECTED)
- LDEF HAS PROVIDED STATISTICALLY SIGNIFICANT IONIZING MEASUREMENTS IN SPACE

CONTAMINATION:

- SILICONES MOST PREVALENT MOLECULAR CONTAMINANT
- UV AND AO EXPOSURE ATTACHED MOLECULAR CONTAMINATION TO LDEF SURFACES. HOWEVER, ON SOME LEADING SURFACES, AO ERODED CONTAMINATION
- CONTAMINATION OF THERMAL CONTROL SURFACES INCREASES SOLAR ABSORBTANCE. CONTAMINATION OF SOLAR CELL COVERS DECREASES SOLAR TRANSMISSION TO SOLAR CELL

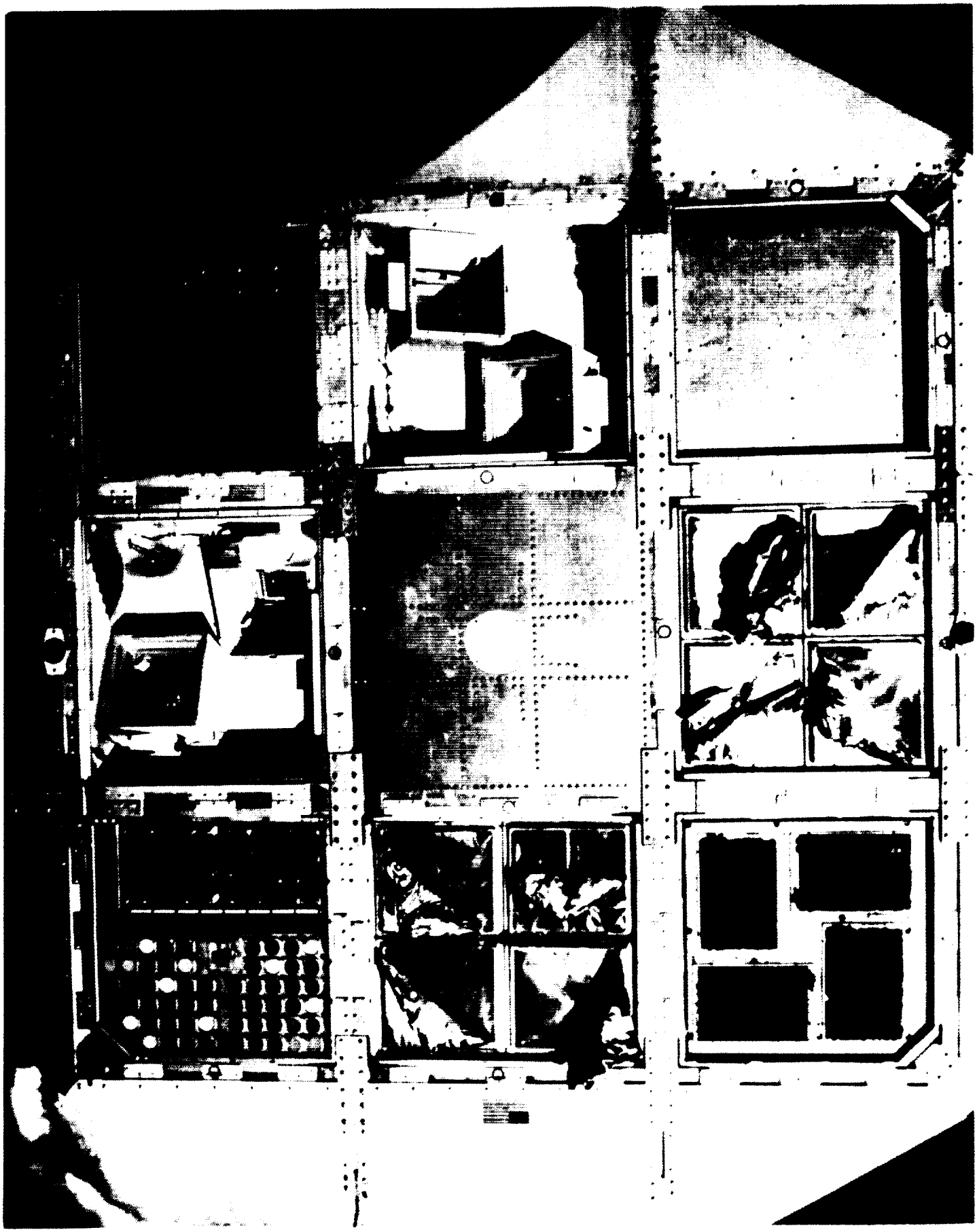
LONG DURATION EXPOSURE FACILITY SUMMARY (cont'd)

MATERIALS:

- UNEXPECTED ENVIRONMENTAL DEGRADATION OF MANY THERMAL CONTROL COATINGS
- SILOXANE-CONTAINING POLYMER FILMS MORE RESISTANT TO ATOMIC OXYGEN (AO) EROSION THAN TEFLON
- UNCOATED POLYMER-MATRIX COMPOSITES NOT RESISTANT TO ATOMIC OXYGEN EROSION
- 1000 ANGSTROM ALUMINUM COATING ON STAINLESS STEEL SUBSTRATE IS STABLE MIRROR/REFLECTOR SURFACE FOR INFRARED APPLICATIONS
- FIBER-REINFORCED ALUMINUM-MATRIX COMPOSITES EXTREMELY STABLE
- OXIDATION OF ALL THIN METALLIC FILMS (EXCEPT TIN AND PLATINUM) SHOWED EVIDENCE OF AT LEAST SLIGHT OXIDATION
- OPTICAL PROPERTIES OF GLASSES AFFECTED IN UV SPECTRAL REGIONS ONLY (DEGRADATION FROM SILICONE CONTAMINATION)

SYSTEMS:

- PASSIVE STABILITY/VISCOUS DAMPER FUNCTIONED WELL
- BATTERIES AND WIRING HARNESSES PERFORMED WELL
- SILVER AND COPPER COATINGS ON OPTICAL SURFACES WERE OXIDIZED (REDUCES EFFICIENCY). DIELECTRIC AND METALLIC COATINGS WERE DELAMINATED BY THERMAL EFFECTS



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LONG DURATION EXPOSURE FACILITY (LDEF) IONIZING RADIATION

NASA — LaRC — OAST

RM

SHOWN

- BERYLLIUM 7 (COSMIC RADIATION BY-PRODUCT) DISTRIBUTION AROUND LDEF

OBJECTIVE

- TO ANALYZE LDEF IONIZING RADIATION DATA AND COSMIC RADIATION BY-PRODUCTS IN ORDER TO REFINE ENVIRONMENT, ATMOSPHERIC TRANSPORT, AND SPACECRAFT SHIELDING MODELS

ACCOMPLISHMENT

- ANALYZED LDEF IONIZING RADIATION DATA
  - DISCOVERED BERYLLIUM 7 ON ALL LDEF LEADING SURFACES (ABSENT ON THE TRAILING SURFACES DUE TO LDEF FIXED ATTITUDE)

BENEFITS

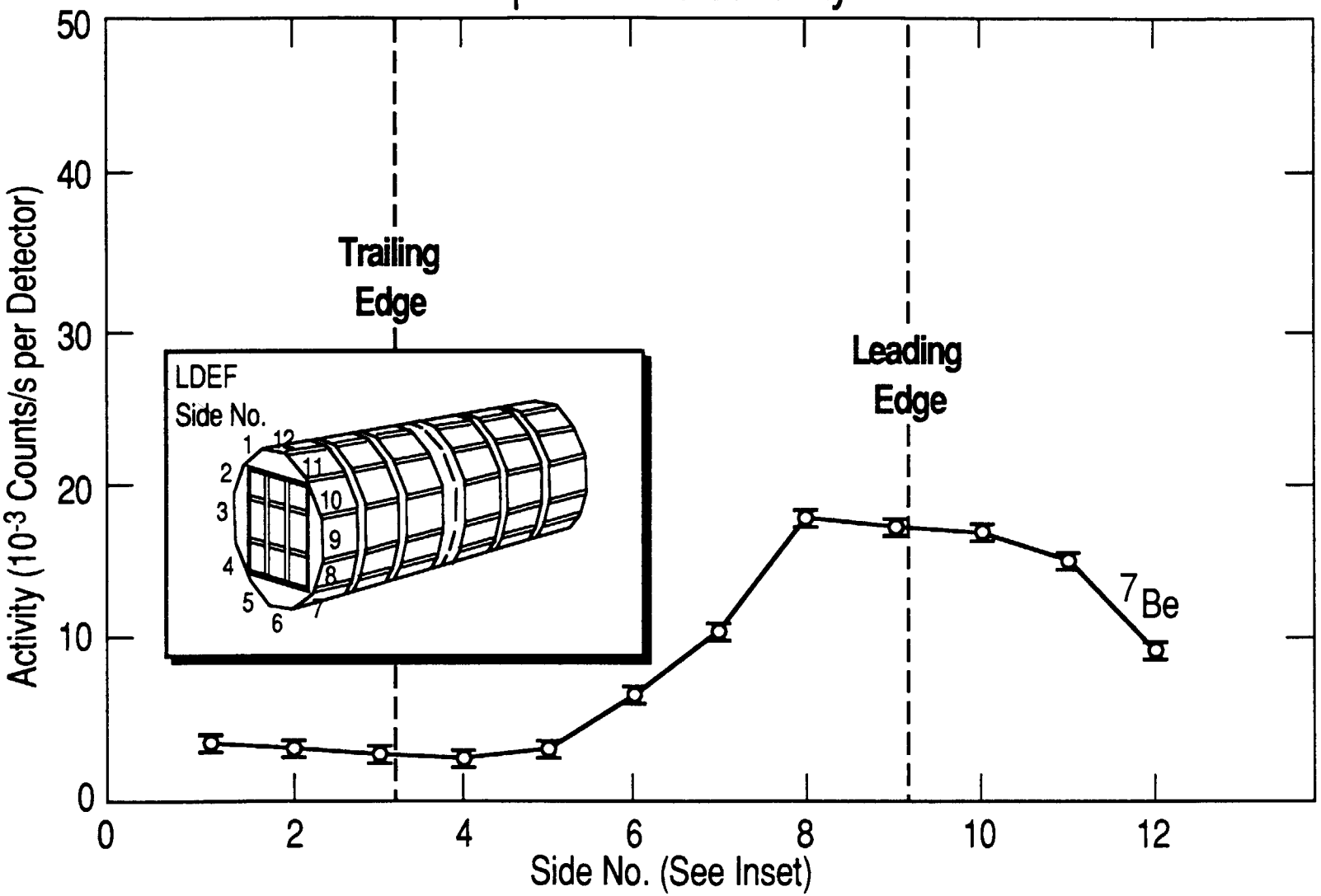
- ENABLES REFINEMENT OF ATMOSPHERIC TRANSPORT MODELS (10-1000 X HIGHER CONCENTRATION OF COSMIC RADIATION BY-PRODUCT IN UPPER ATMOSPHERE THAN EXPECTED)
- FURTHER UNDERSTANDING OF COSMIC RAY BOMBARDMENT AND ASSOCIATED ATMOSPHERIC PROCESSES ENABLES REFINEMENT OF SPACECRAFT SHIELDING REQUIREMENTS

APPLICABLE MISSIONS

- LOW EARTH ORBIT MISSIONS

LDEF (Total Spacecraft)

Acquired Radioactivity



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LONG DURATION EXPOSURE FACILITY (LDEF) METEOROID AND DEBRIS

NASA — LaRC — OAST

RM

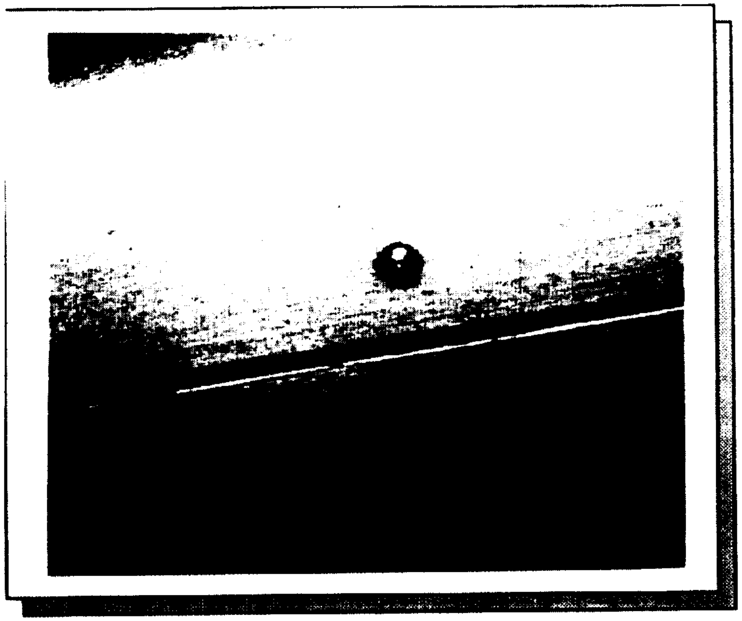
SHOWN
- METEROID AND DEBRIS IMPACTS ON LDEF EXPERIMENTS

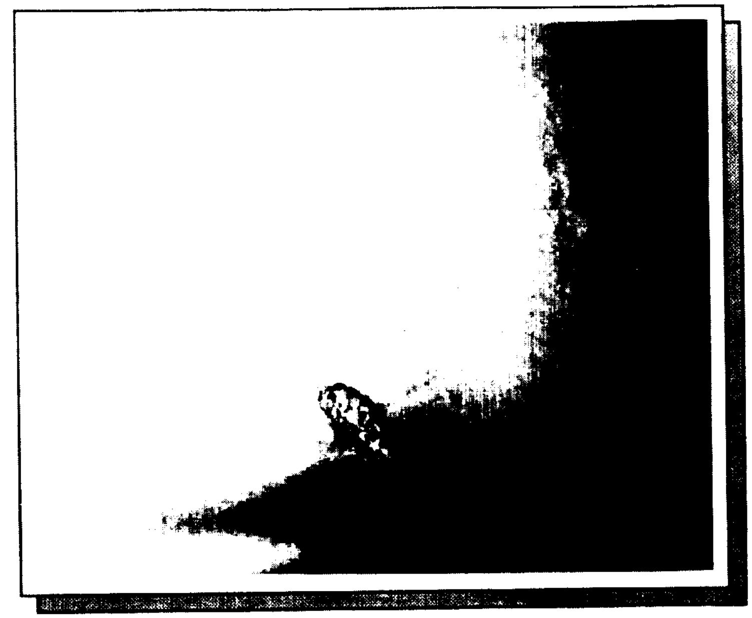
OBJECTIVE
- TO ANALYZE LDEF METEOROID AND DEBRIS DATA IN ORDER TO REFINE AND SIGNIFICANTLY IMPROVE CONFIDENCE IN SPACECRAFT METEOROID AND DEBRIS MODELS

ACCOMPLISHMENT
- OBTAINED SAMPLES OF METEOROID AND DEBRIS IMPACT DAMAGE ON TYPICAL SPACECRAFT SURFACES
- ANALYZED LDEF METEOROID AND DEBRIS DATA AND IDENTIFIED ERRORS IN EXISTING METEOROID AND DEBRIS MODELS:
  - SMALL PARTICLE FLUX, OVER PREDICTED
  - LARGE PARTICLE FLUX, UNDER PREDICTED
  - ANISOTROPIC DIRECTIONALITY, UNDER PREDICTED

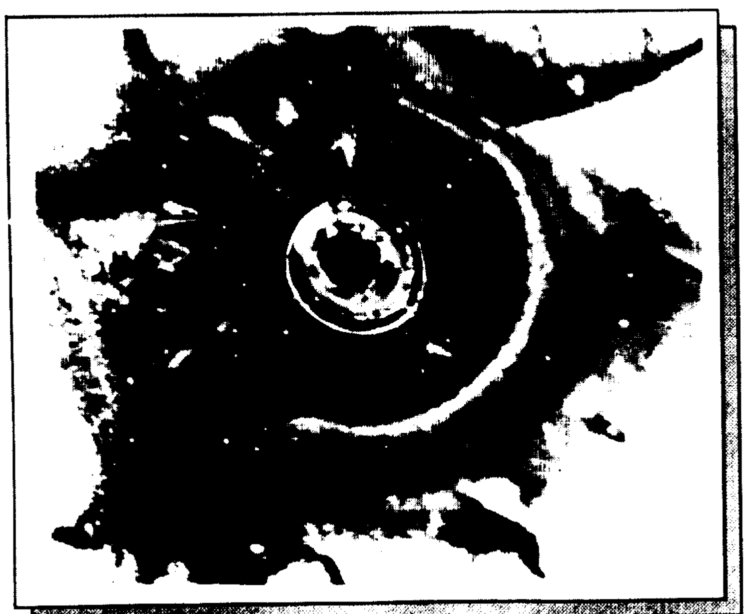
BENEFITS
- ENABLES MORE ACCURATE PREDICTIONS OF METEOROID/DEBRIS FLUX IMPACT DAMAGE
- ENABLES MORE EFFICIENT DESIGNS FOR METEOROID AND DEBRIS SHIELDING

APPLICABLE MISSIONS
- SPACE STATION FREEDOM
- EARTH OBSERVING SYSTEM
- SPACE EXPLORATION

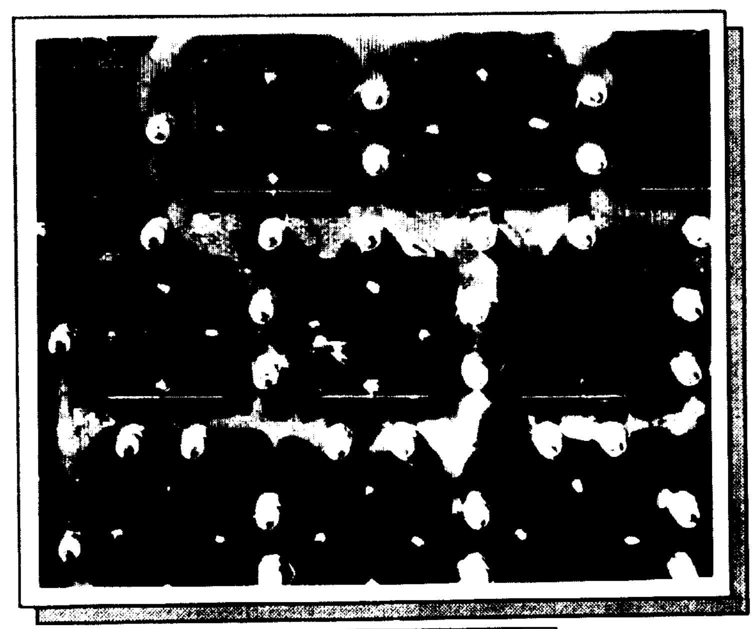




THICK ALUMINUM PLATES



THIN LAMINATED PLASTICS



SOLAR ARRAY

MULTI-FLEXIBLE BODY DYNAMIC MODELING TOOLS

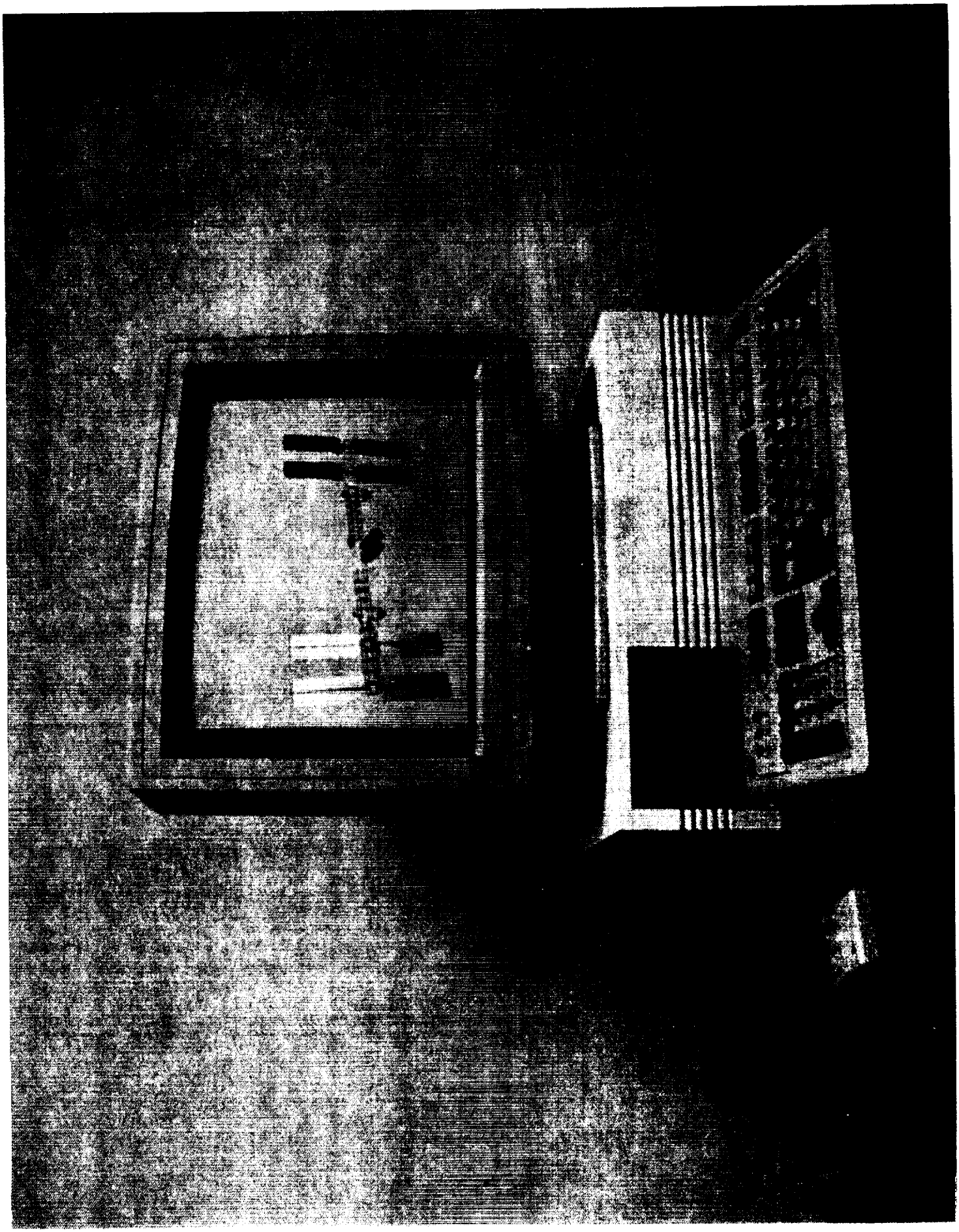
NASA — JSC — OAST

RC

SHOWN	● SPACE STATION COMPUTATIONAL CONTROLS WORKSTATION WITH THE PARALLEL PROCESSING UNIT
OBJECTIVE	● TO DEVELOP INNOVATIVE TECHNIQUES, SOLUTION ALGORITHMS, SOFTWARE, AND HARDWARE ARCHITECTURES TO FORM A COMPUTATIONAL CONTROL WORKSTATION THAT UTILIZES THE ADVANTAGES OF PARALLEL PROCESSING COMPUTATIONS
ACCOMPLISHMENT	● DEVELOPED AND DEMONSTRATED ORDER-N MULTI-FLEXIBLE BODY DYNAMIC MODELING TOOLS ON A PARALLEL COMPUTATIONAL CONTROLS ANALYSIS WORKSTATION
BENEFITS	● QUANTUM LEAP IN SIMULATION TECHNOLOGY ● ENABLES REAL-TIME SIMULATION OF FLEXIBLE BODY MODELS FOR SPACE STATION ASSEMBLY ● PROVIDES ULTRA-FAST PARALLEL PROCESSING ARCHITECTURE IN DESKSIDE ENVIRONMENT ● PROVIDES CONSISTENT USER FRIENDLY INTERFACE AND STATE-OF-THE-ART POST-PROCESSING OPTIONS ● ENABLES USERS TO UNDERSTAND AND PERFORM ANALYSIS FASTER THROUGH ANIMATION OF MOTION
APPLICABLE MISSIONS	● SPACE STATION FREEDOM

INFORMATION & CONTROLS FY91

R&T BASE



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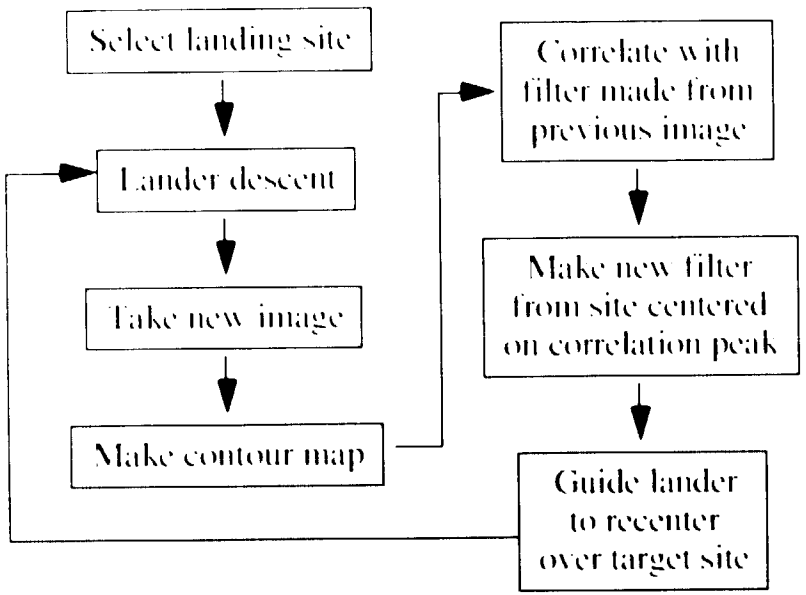
PHOTONIC DEVICES FOR PLANETARY LANDER

NASA — ARC — OAST — RC

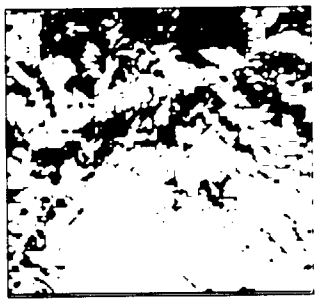
SHOWN	● TYPICAL MARS TERRAIN IMAGE AND SEQUENCE OF STEPS TO MEASURE LOCATION OF LANDING SITE IN THE IMAGE
OBJECTIVE	● TO DEVELOP OPTICAL PATTERN RECOGNITION TECHNOLOGY FOR AUTONOMOUS PLANETARY LANDING TO ALLOW CLOSED-LOOP LANDER CONTROL AND MEASUREMENT OF LANDER VELOCITY
ACCOMPLISHMENT	● DEMONSTRATED CONTROL OF PLANETARY LANDER MOCKUP USING PHOTONIC DEVICES (BINARY PHASE-ONLY FILTERS)
BENEFITS	● 10X SMALLER LANDING AREA FOOTPRINT THAN PREVIOUS LANDERS ● SAFE SET DOWN 10X CLOSER TO INTERESTING TERRAIN FEATURES ● 16% SCALE DISTORTION TOLERANCE BETWEEN SUBSEQUENT IMAGES ● MEASUREMENT OF VELOCITY USING ONLY LANDER CAMERA
APPLICABLE MISSIONS	● MARS ROVER SAMPLE RETURN (MRSR) ● MARS ENVIRONMENTAL SURVEY (MESUR)

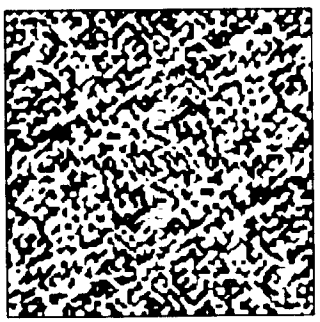
Terrain Recognition for Lander Guidance

Landing sequence:

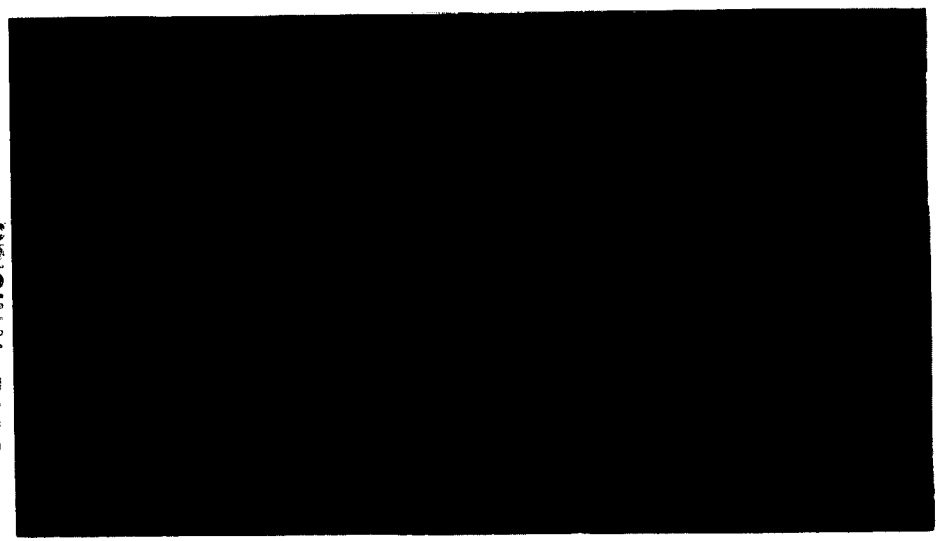



Terrain Image


Contour Map


Target Filter


Correlation



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Applications

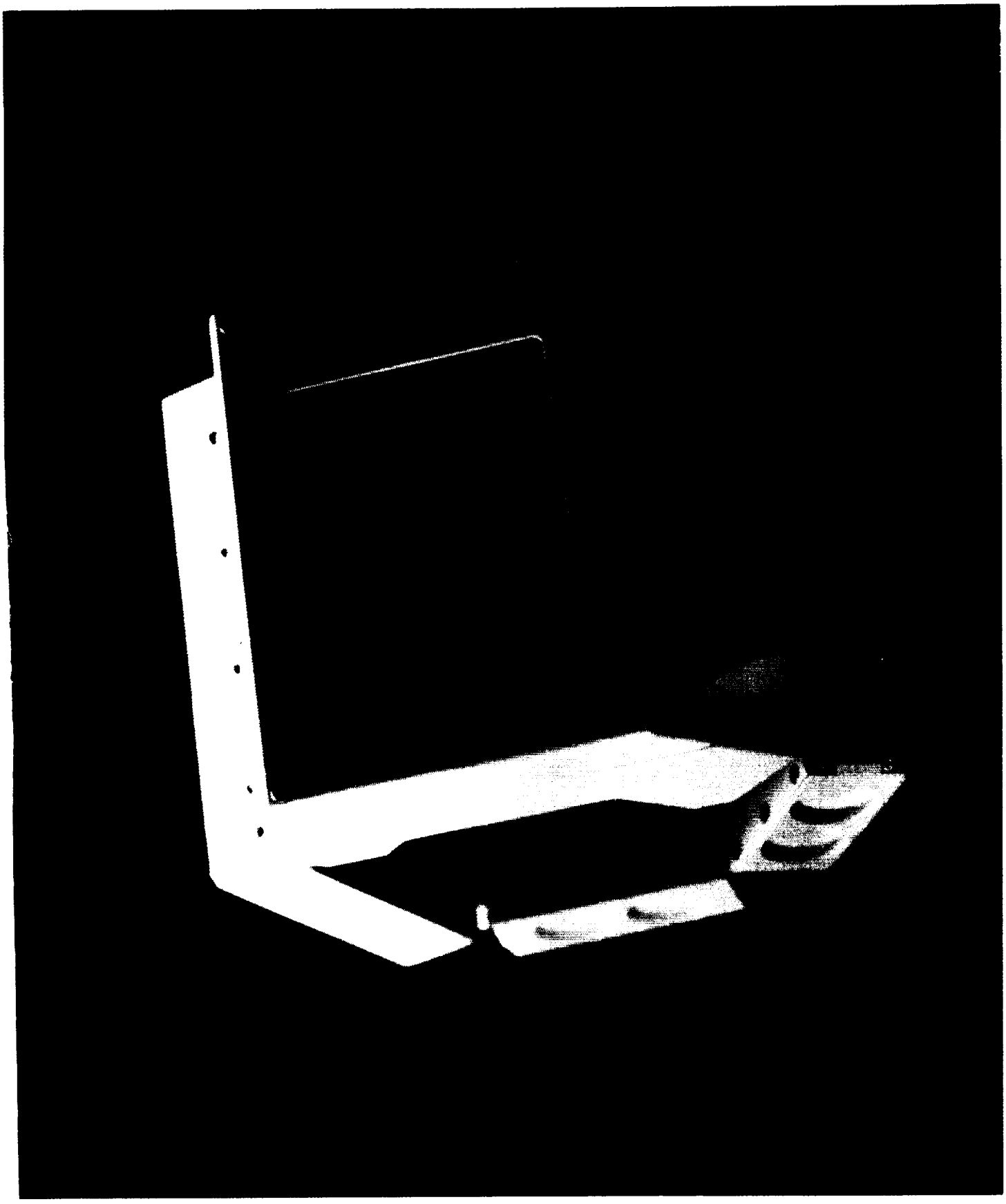
- Mars Rover Sample Return Lander footprint reduction.
- Mars Environmental Survery Lander velocity and altitude measurement.

NASA
Ames Research Center

EXTRAVEHICULAR ACTIVITY (EVA) EXTRAVEHICULAR MOBILITY UNIT (EMU) ELECTRONIC CUFF CHECKLIST

NASA — JSC — OAST — RC

SHOWN	● EVA EMU ELECTRONIC CUFF CHECKLIST
OBJECTIVES	● TO DESIGN, DEVELOP, AND TEST A FUNCTIONAL PROTOTYPE OF AN EXTRAVEHICULAR MOBILITY UNIT (EMU) ELECTRONIC CUFF CHECKLIST
ACCOMPLISHMENTS	● DEVELOPED FUNCTIONAL PROTOTYPE OF EXTRAVEHICULAR MOBILITY UNIT (EMU) ELECTRONIC CUFF CHECKLIST FOR POTENTIAL USE AS REPLACEMENT TO CURRENT PAPER PROCEDURAL CHECKLIST
BENEFITS	● SIGNIFICANTLY IMPROVES ASTRONAUT EVA PRODUCTIVITY - 20X LARGER DATABASE (>200 PAGES) - LESS CUMBERSOME TO USE - LESS TIME-CONSUMING TO ASSEMBLE (10X FASTER) - UP-TO-DATE WITH CURRENT TRAINING PROCEDURES ● BETTER CONFIGURATION MANAGEMENT CONTROL BY UTILIZING ACCESS-CONTROLLABLE ELECTRONIC DATABASE
APPLICABLE MISSIONS	● SPACE STATION FREEDOM ● SPACE SHUTTLE



VIRTUAL ENVIRONMENT FACILITY

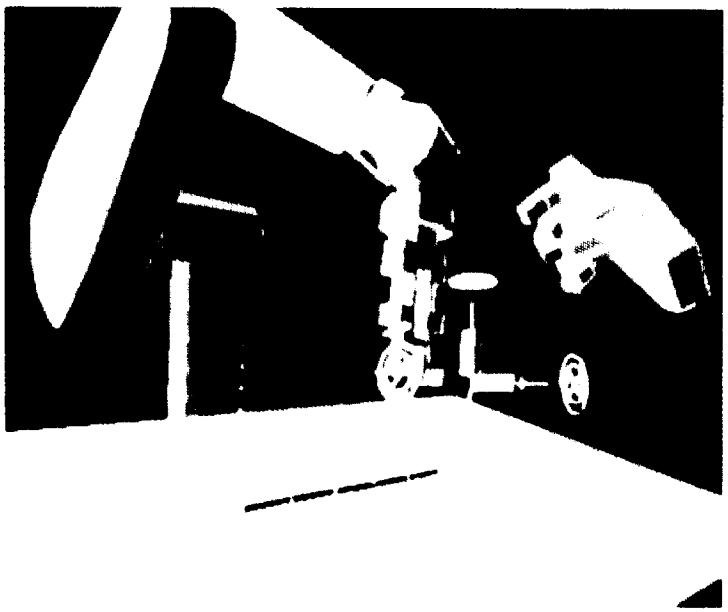
NASA — ARC — OAST

RC

SHOWN	● VIRTUAL ENVIRONMENT DISPLAY FOR TELEOPERATIONS AND TELEROBOTIC PLANNING
OBJECTIVES	● TO DEVELOP VIRTUAL ENVIRONMENT TECHNOLOGY FOR NASA MISSIONS IN ORDER TO PROVIDE A UNIQUE MEANS OF EMERSING THE USER IN A REAL OR HYPOTHETICAL SIMULATION SUCH THAT THE USER EXPERIENCES OBJECTS AND SITUATIONS AS IF THEY WERE REAL
ACCOMPLISHMENTS	● DEVELOPED SOFTWARE TO DEMONSTRATE VIRTUAL REALITY CONTROL OF TELEROBOTIC MANIPULATOR ● DEVELOPED SOFTWARE TO DEMONSTRATE USE OF VIRTUAL REALITY FOR AEROTHERMODYNAMIC APPLICATIONS
BENEFITS	● PROVIDES QUICK PROTOTYPE WHICH CAN BE EASILY TESTED TO REFINE CONCEPTS AND IDEAS ● ENABLES MISSION ANALYSIS AND TRAINING AT VERY LOW COST WHICH WOULD OTHERWISE REQUIRE EXPENSIVE REAL WORLD FACILITIES (SUCH AS A WIND TUNNEL OR LARGE- SCALE MOCKUP OF A LUNAR SURFACE) ● ENABLES IMPROVED TELEOPERATION PLANNING, ASTRONAUT MISSION TRAINING, AND ADVANCED AEROTHERMODYNAMIC ANALYSIS
APPLICABLE MISSIONS	● SPACE STATION FREEDOM ● SPACE EXPLORATION INITIATIVE MISSIONS

Virtual Environment Display for Teleoperations & Telerobotic Planning

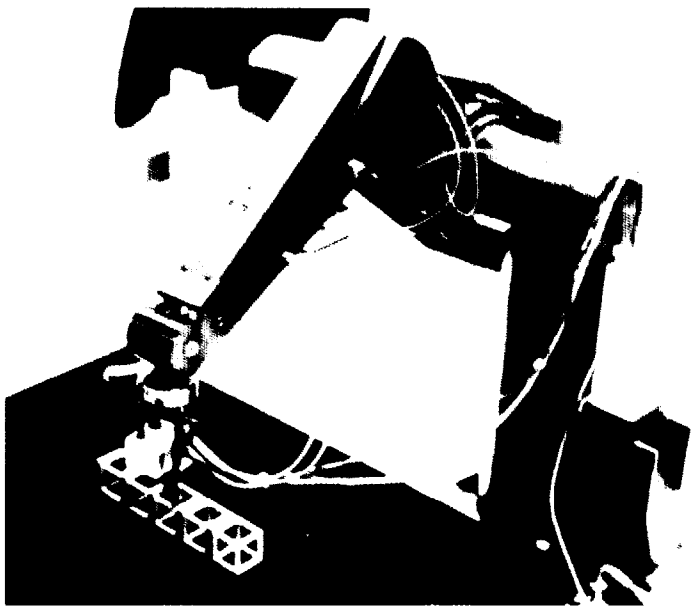
Virtual Workplace



Video

Ethernet

Real Workplace



AMT MOBILE COMMUNICATIONS

NASA — JPL — OAST

RC

SHOWN	● SMALL REFLECTOR ANTENNA TRACKING A PSEUDO SATELLITE SIGNAL USING MECHANICAL DITHERING
OBJECTIVE	● TO DEVELOP AN ANTENNA FOR LAND-MOBILE SATELLITE COMMUNICATIONS AT Ka-BAND
ACCOMPLISHMENT	● DEVELOPED ADVANCED COMMUNICATION TECHNOLOGY SATELLITE (ACTS) MOBILE TERMINAL (AMT) SMALL REFLECTOR ANTENNA AND DEMONSTRATED TRACKING OF A PSEUDO SATELLITE SIGNAL
BENEFITS	● SMALL REFLECTOR ANTENNA IS LOW-PROFILE, ROBUST, AND LOW-COST FOR LAND-MOBILE APPLICATIONS ● PROVIDES SIGNIFICANT SIMPLIFICATION OF RF ELECTRONICS THROUGH USE OF TRACKING BASED ON MECHANICAL DITHERING VERSUS PSEUDO-MONOPULSE)
APPLICABLE MISSIONS	● SPACE EXPLORATION INITIATIVE MISSIONS ● ROVER MISSIONS

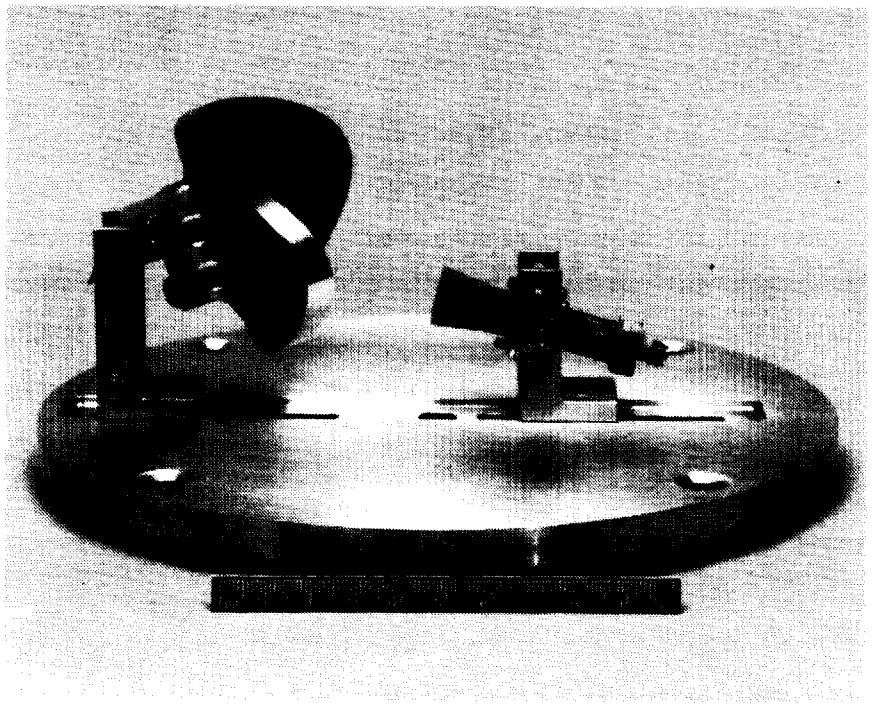
JPL

ACTS MOBILE SATCOM TECHNOLOGY PROGRAM

MOBILE TERMINAL ANTENNAS

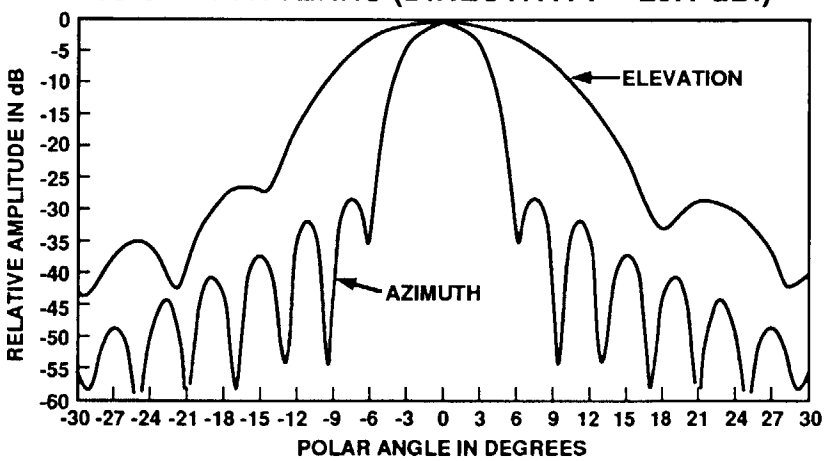
- MEDIUM GAIN (22 dBi), MECHANICALLY STEERED, SMALL REFLECTOR AND ACTIVE ARRAY UNDER DEVELOPMENT

REFLECTOR ANTENNA TESTBED

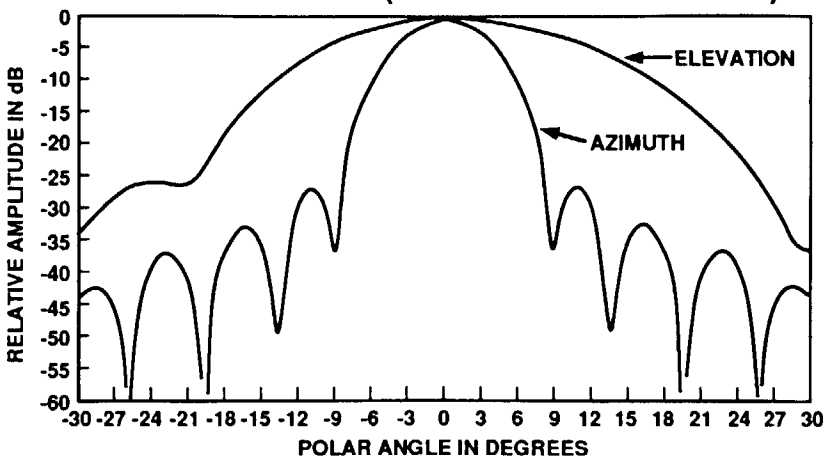


PREDICTED REFLECTOR ANTENNA PATTERNS

30 GHz PATTERNS (DIRECTIVITY = 28.1 dBi)



20 GHz PATTERNS (DIRECTIVITY = 24.54 dBi)



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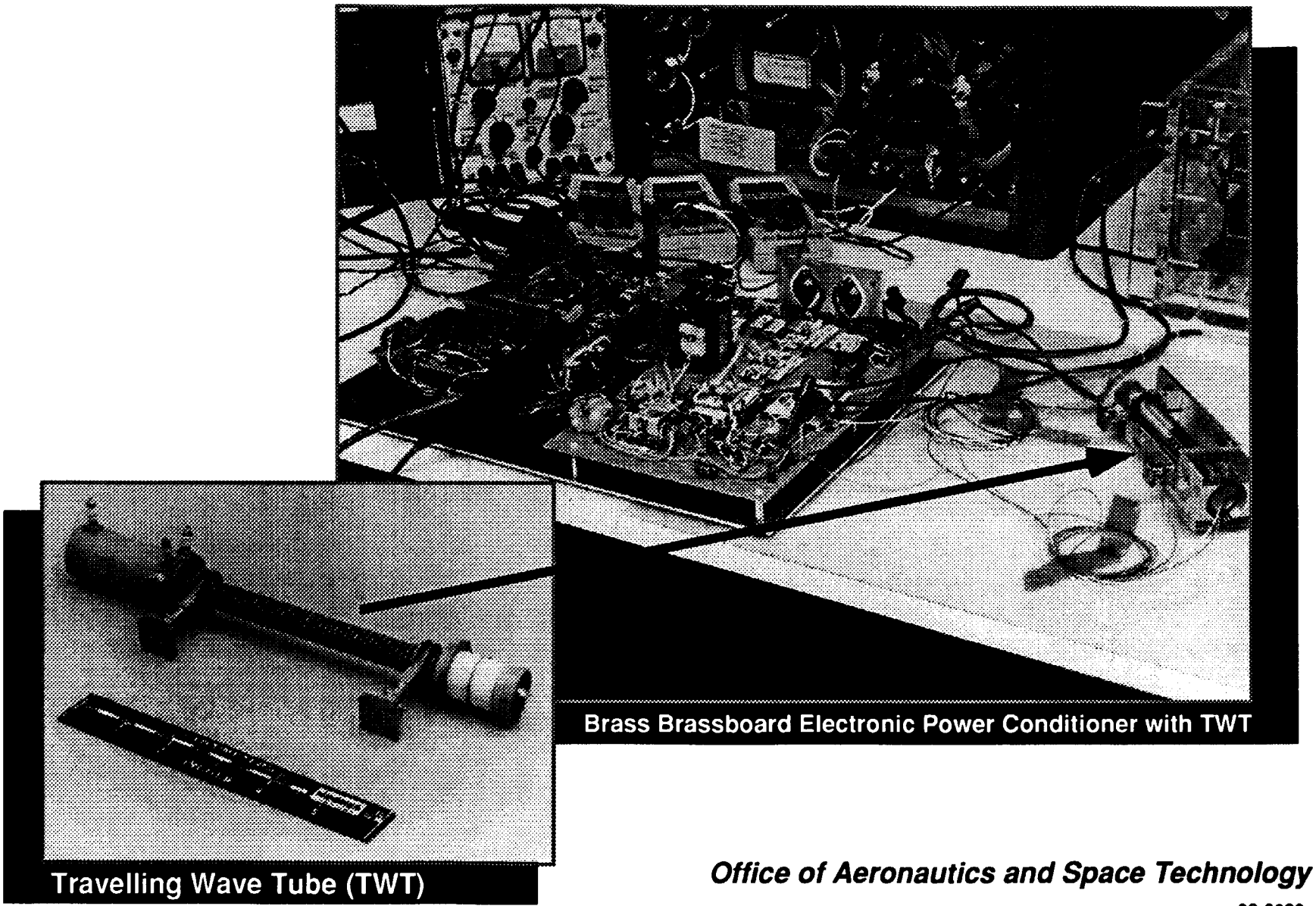
HIGH EFFICIENCY Ka-BAND (32 GHz) TRAVELLING WAVE TUBE AMPLIFIER (TWTA) FOR CASSINI

NASA — LeRC — OAST — RC

SHOWN	● PRELIMINARY TECHNOLOGY TRAVELING WAVE TUBE AMPLIFIER (TRAVELLING WAVE TUBE ON RIGHT, BRASSBOARD ELECTRONIC POWER CONDITIONER ON LEFT)
OBJECTIVE	● TO IMPROVE EFFICIENCY AND RF OUTPUT POWER OF A 32 GHz LOW-POWER (10 WATTS) TRAVELING WAVE TUBE AMPLIFIER IN ORDER TO MEET THE COMMUNICATIONS REQUIREMENTS OF THE CASSINI MISSION TO SATURN
ACCOMPLISHMENT	● IMPROVED TWTA EFFICIENCY AND RF OUTPUT POWER
BENEFITS	● 2X IMPROVEMENT IN EFFICIENCY (40%) COMPARED TO CURRENT STATE-OF-THE-ART SPACE QUALIFIED TWTAs (20%) ● 2X IMPROVEMENT IN RF OUTPUT POWER FROM 5 WATTS TO 10 WATTS ● Ka-BAND OFFERS IMPROVED COMMUNICATIONS FROM DEEP SPACE - ENABLES TRANSMISSION TO EARTH OF ALL CASSINI MISSION DATA (X-BAND SYSTEM CAPABLE OF TRANSMITTING ONLY 1/3 OF MISSION DATA)
APPLICABLE MISSIONS	● CASSINI ● LUNAR/MARS MISSIONS ● SOLAR PROBE



Brass Brassboard Electronic Power Conditioner with TWT

Travelling Wave Tube (TWT)

Office of Aeronautics and Space Technology

92-8029

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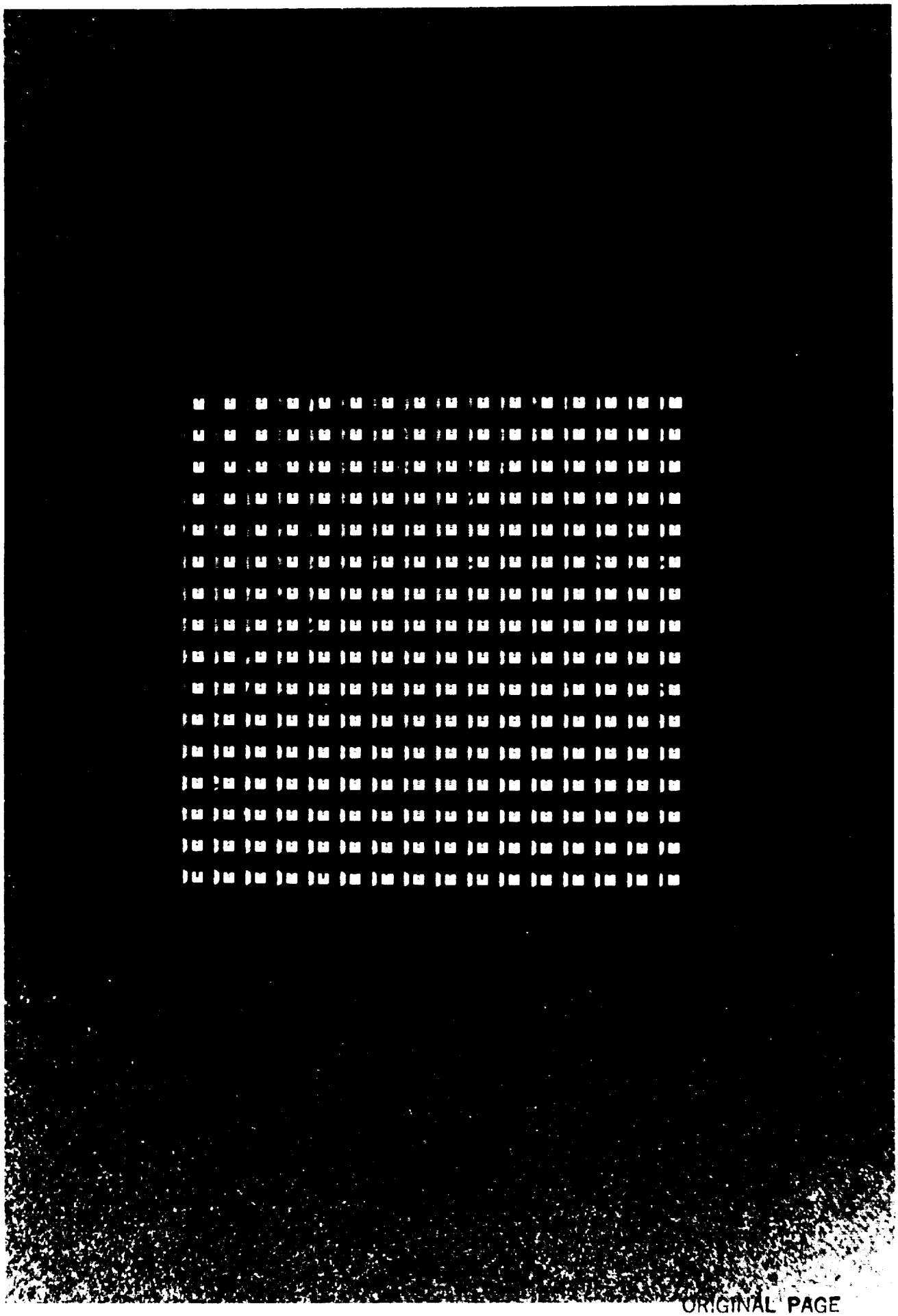
FIRST TERAHERTZ FOCAL PLANE ARRAY

NASA — UNIVERSITY OF MICHIGAN — OAST

RS

SHOWN	● 16x16 (256 ELEMENT) 0.8 THz FOCAL PLANE ANTENNA ARRAY
OBJECTIVE	● TO DEVELOP REMOTE SENSING TECHNOLOGIES IN THE TERAHERTZ REGION OF THE ELECTROMAGNETIC SPECTRUM
ACCOMPLISHMENT	● DEVELOPED FIRST SQUARE ANTENNA ARRAY OPERATING NEAR THE TERAHERTZ RANGE (0.8 THz) FOR INTEGRATION INTO SENSOR SYSTEM
BENEFITS	● TERAHERTZ ARRAY TECHNOLOGY WILL ENABLE REMOTE SENSING OF CRITICAL CHEMICAL SPECIES - FOR THE STUDY OF THE MAKE-UP OF DISTANT INTERSTELLAR GAS CLOUDS - FOR THE STUDY OF OZONE AND OZONE DEPLETION IN THE UPPER ATMOSPHERE OF THE EARTH
APPLICABLE MISSIONS	● UPPER ATMOSPHERE EARTH SCIENCE MISSIONS ● SUBMILLIMETER ASTROPHYSICS MISSIONS



MICRO-SENSOR FOR FLOW MEASUREMENTS

NASA — UNIVERSITY OF CINCINNATI — OAST

RS

SHOWN
- MICRO-SENSOR FOR FLUID VELOCITY MEASUREMENTS, ON A HUMAN FINGERTIP

OBJECTIVE
- TO DEVELOP TECHNOLOGIES FOR MONITORING AND VERIFYING THE HEALTH AND PERFORMANCE OF SPACE VEHICLES AND PROPULSION SYSTEMS

ACCOMPLISHMENT
- DEMONSTRATED MICRO-SENSOR THAT CAN BE ADAPTED OVER FULL RANGE OF ENGINE ENVIRONMENTS
  - AT HIGH TEMPERATURES (e.g. FOR COMBUSTION CHAMBERS)
  - AT CRYOGENIC TEMPERATURES (e.g. FOR PUMP AND FUEL LINES)
- DEVELOPED NOVEL BRAZING TECHNIQUE FOR ATTACHING SENSOR TO ENGINE INTERIOR

BENEFITS
- SMALL SENSOR SIZE ALLOWS ACCURATE MEASUREMENT WITHOUT DISRUPTING FLUID FLOW
- BRAZING TECHNIQUE ENABLES SENSOR-ENGINE ATTACHMENT IN SECONDS vs. TENS OF HOURS FOR STATE-OF-THE-ART ATTACHMENT TECHNIQUES
- SENSOR CAN BE USED TO MEASURE FLOW OF ANY LIQUID OR GAS (e.g. FOR PROPULSION, LIFE SUPPORT, CRYOGENIC COOLING FLUID)

APPLICABLE MISSIONS
- PROPULSION SYSTEMS
- ANY MISSION USING FLUIDS THAT REQUIRE REAL-TIME, NON-INTRUSIVE MONITORING

CO_2-TO-OXYGEN DEMONSTRATION PLANT

NASA — UNIVERSITY OF ARIZONA — OAST

RS

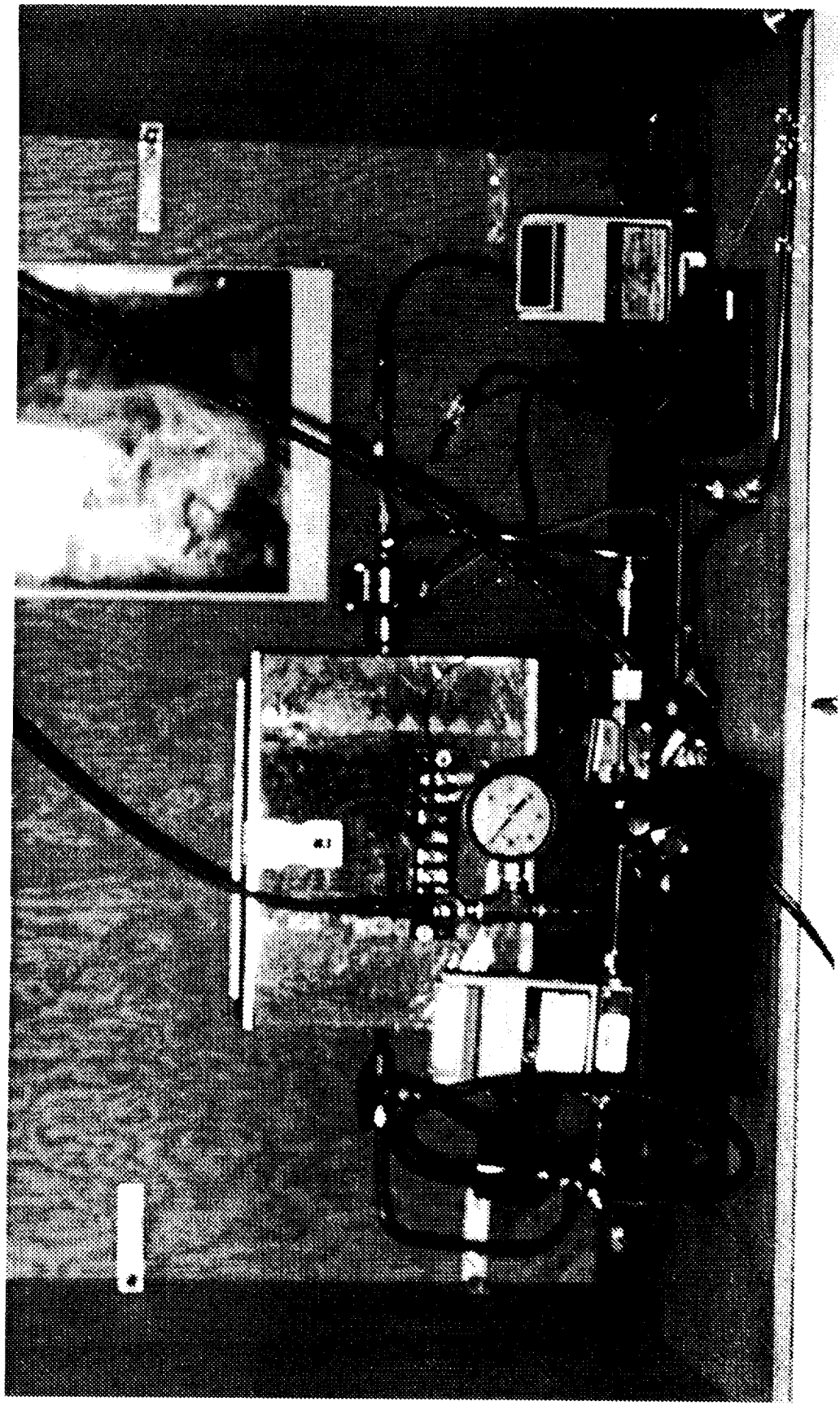
SHOWN
- THE CO_2-TO-OXYGEN TEST SYSTEM

OBJECTIVE
- TO DEVELOP TECHNOLOGIES FOR THE PRODUCTION OF OXYGEN, HYDROGEN, AND OTHER VOLATILES, METALS, GLASS/CERAMICS, AND COMPOSITES FROM LUNAR REGOLITH AND THE MARTIAN ATMOSPHERE

ACCOMPLISHMENT
- DEMONSTRATED ZIRCONIUM-BASED TEST CELL TO SEPARATE OXYGEN FROM CARBON DIOXIDE
  - GENERATED MORE THAN 10 GRAMS/DAY
- CONDUCTED EXTENSIVE TESTS ON SINGLE CELL SYSTEM AND LIMITED TESTING OF 16 CELL SYSTEM

BENEFITS
- ENABLES *IN SITU* GENERATION OF OXYGEN FROM MARTIAN ATMOSPHERE
  - USEFUL FOR LIFE SUPPORT, BUT GREATEST BENEFIT IS FOR OXYGEN-BASED PROPULSION SYSTEM REFUELING
- ENABLES SIGNIFICANT REDUCTION IN EARTH-TO-ORBIT MASS REQUIREMENTS OF LONG-TERM MARS MISSIONS

APPLICABLE MISSIONS
- MARS EXPLORATION MISSIONS
- MARS COLONIZATION MISSIONS



ORBITAL ACCELERATION RESEARCH EXPERIMENT (OARE)

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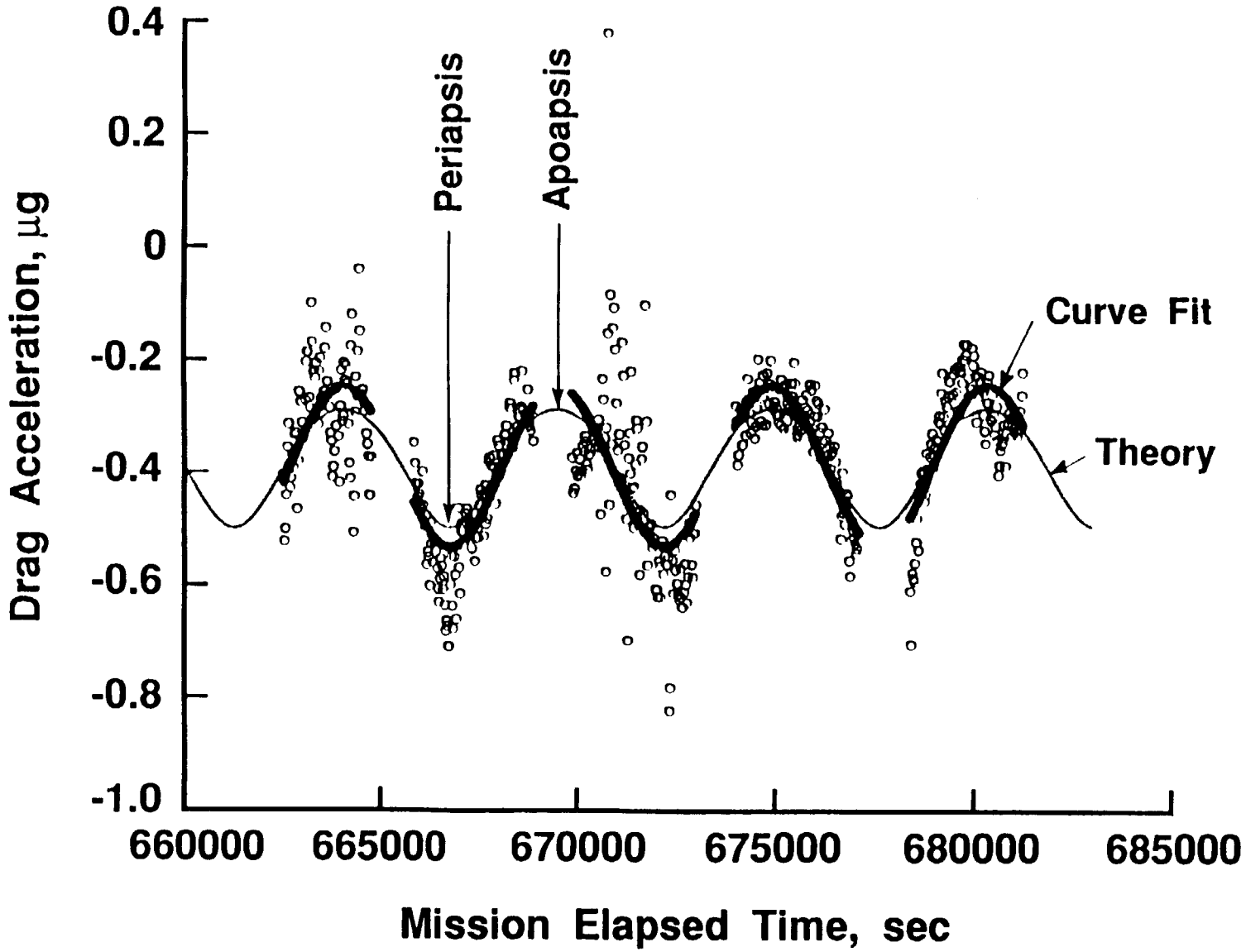
RX

SHOWN	● ORBITER PERIODIC DRAG ACCELERATION MEASUREMENTS OVER 3 1/2 ORBITS DURING STS-40 MISSION
OBJECTIVES	● TO DETERMINE AERODYNAMIC FORCES ACTING ON THE SHUTTLE ORBITER ON-ORBIT AND DURING THE HIGH-ALTITUDE (FREE-MOLECULAR AND TRANSITIONAL FLOW) PORTION OF ATMOSPHERIC ENTRY
ACCOMPLISHMENTS	● DEMONSTRATED CAPABILITY TO SENSE AERODYNAMIC FORCES (MICRO-G ACCELERATION LEVELS) AT SHUTTLE ORBITAL ALTITUDES
BENEFITS	● ENABLES VALIDATION OF STATE-OF-THE-ART DESIGN TECHNIQUES (3D RAREFIED FLUID FLOWS, ORBITAL DRAG AND ORBITAL DECAY PREDICTIONS) FOR VEHICLES THAT WILL OPERATE AT HIGH ALTITUDES WITHIN THE ATMOSPHERE AND IN LOW-EARTH ORBIT
APPLICABLE MISSIONS	● SPACE STATION FREEDOM ● ADVANCED SPACE TRANSPORTATION

OARE SENSES PERIODIC ORBITAL DRAG VARIATION



SHUTTLE INFRARED LEESIDE TEMPERATURE SENSING (SILTS)

NASA — LaRC — OAST

RX

SHOWN
- TYPICAL TEMPERATURE VARIATION OVER ORBITER LEESIDE (UPPER SURFACE) FUSELAGE DURING STS-40 ENTRY

OBJECTIVES
- TO OBTAIN HIGH-SPATIAL-RESOLUTION MEASUREMENTS OF SHUTTLE ORBITER LEESIDE SURFACE TEMPERATURE DURING ENTRY

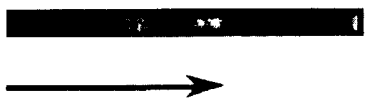
ACCOMPLISHMENTS
- OBTAINED HIGH-SPATIAL-RESOLUTION MEASUREMENTS OF ORBITER LEESIDE SURFACE TEMPERATURE USING A SCANNING INFRARED RADIOMETER LOCATED ATOP ORBITER VERTICAL TAIL (STS-35 AND STS-40)

BENEFITS
- ENABLES VALIDATION OF STATE-OF-THE-ART DESIGN TECHNIQUES (3D FLUID FLOWS) TO BE APPLIED TO ADVANCED HYPERSONIC VEHICLES

APPLICABLE MISSIONS
- ADVANCED SPACE TRANSPORTATION

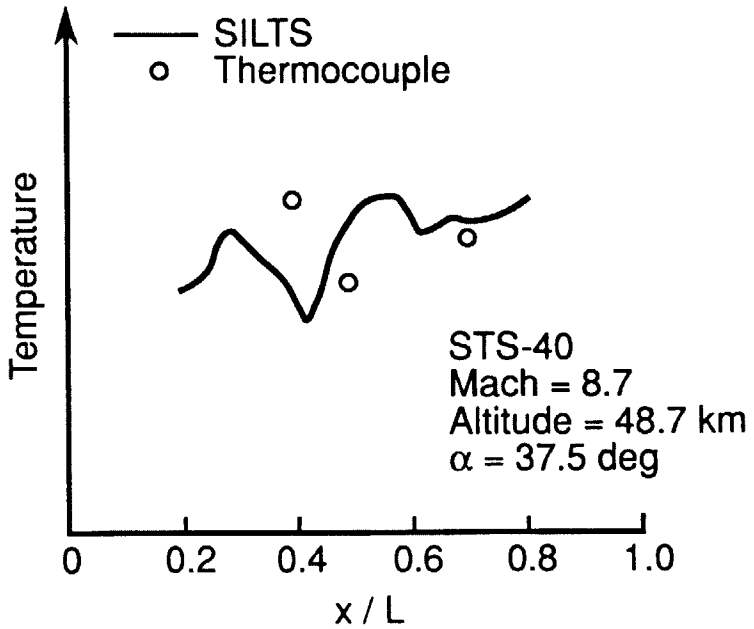
SILTS LEESIDE FUSELAGE TEMPERATURE DATA

TYPICAL IMAGE DATA



Increasing Temperature

CENTERLINE DISTRIBUTION



MIDDECK 0-GRAVITY DYNAMICS EXPERIMENT (MODE)

NASA — LaRC — OAST

RX

SHOWN

- MIT STUDENTS SHOWING THE MCDONNELL DOUGLAS PROVIDED STRUCTURAL TEST ARTICLE

OBJECTIVE

- TO MEASURE MECHANICAL DYNAMICS OF A JOINT TRUSS STRUCTURE AND THE SLOSH DYNAMICS OF FLUIDS IN MICROGRAVITY ENVIRONMENT

ACCOMPLISHMENT

- DEVELOPED AND FLIGHT QUALIFIED A SHUTTLE MIDDECK DYNAMIC TEST FACILITY
- FLOWN SUCCESSFULLY ABOARD STS-48, SEPTEMBER 12-16, 1991
  - OBTAINED APPROXIMATELY 300 MILLION MEASUREMENTS
  - COMPLETED STRUCTURAL AND FLUID DYNAMICS TESTS

BENEFITS

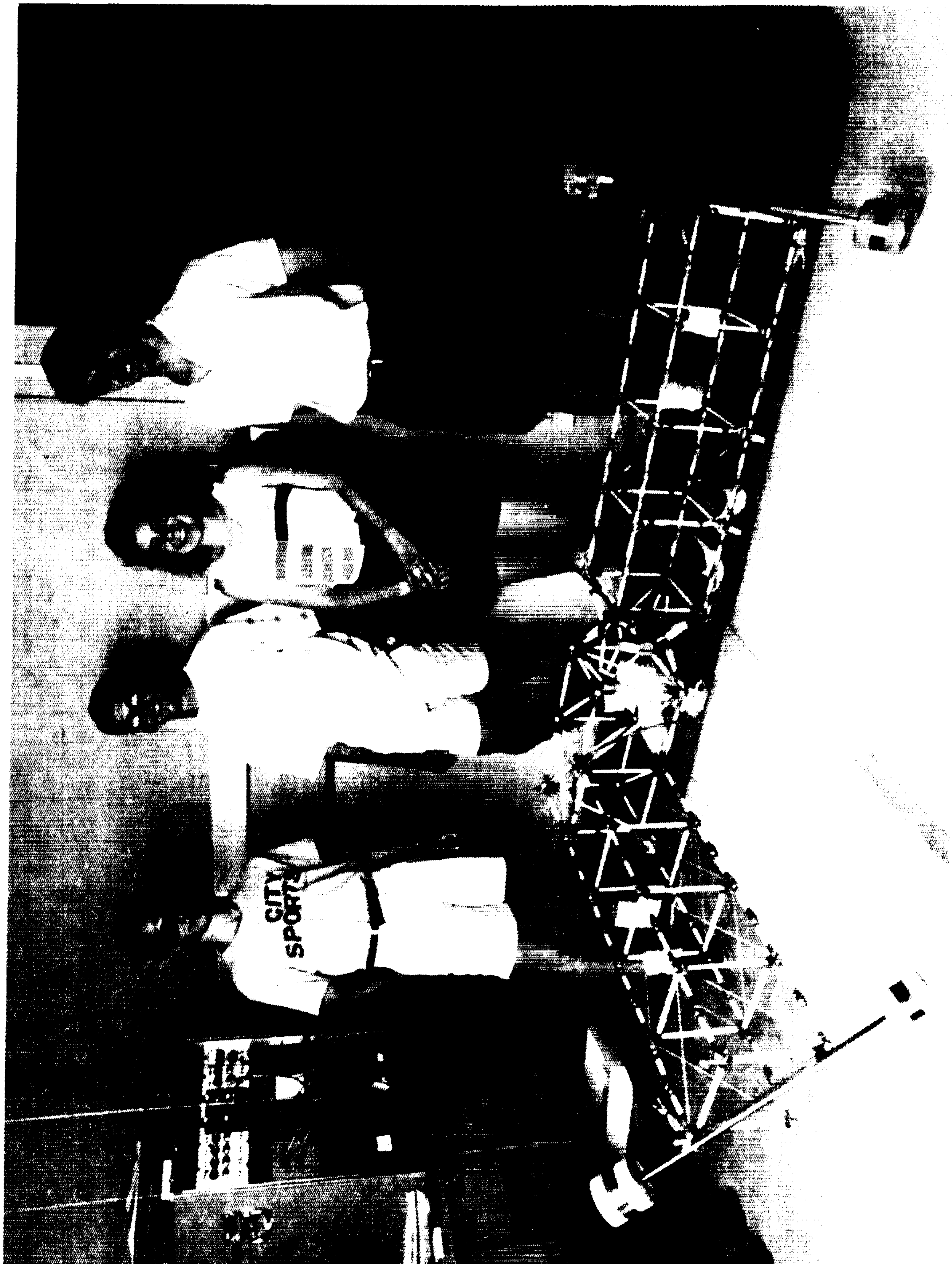
- FIRST SHUTTLE MIDDECK TEST FACILITY CAPABLE OF INDUCING KNOWN DISTURBANCES IN TEST ARTICLES AND MEASURING THEIR DYNAMIC RESPONSES
- STRUCTURAL AND FLUID DYNAMICS MEASUREMENT TESTS INDICATE
  - FEASIBILITY OF LESS CONSERVATIVE SPACECRAFT DESIGN
  - GREATER VISCOSITY EFFECTS THAN MODELS PREDICTED

APPLICABLE MISSIONS

- FUTURE TRANSFER VEHICLES FOR FUEL DEPOTS
- PRECISION STRUCTURES OR SPACECRAFTS
- LARGE FLUID MASS FRACTION SPACECRAFT
- PLANETARY SPACECRAFT
- SPACE STATION FREEDOM

IN-STEP FY91

R&T BASE



TANK PRESSURE CONTROL EXPERIMENT (TPCE)

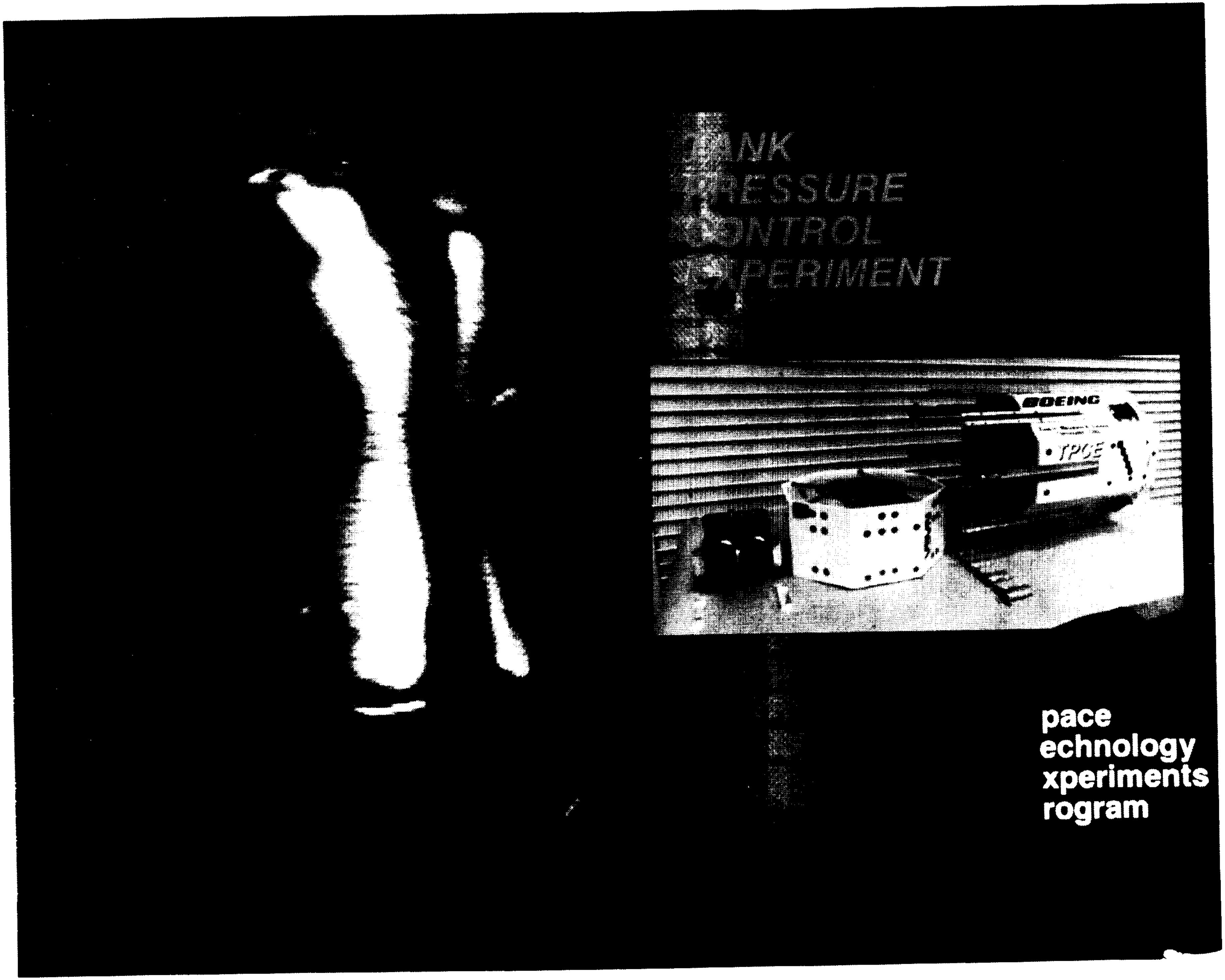
NASA — LeRC — OAST

RX

SHOWN	● TANK PRESSURE CONTROL EXPERIMENT
OBJECTIVES	● INVESTIGATE FLUID DYNAMICS AND THERMODYNAMICS OF JET MIXING AS A MEANS OF PRESSURE CONTROL ● OBTAIN DATA FOR VALIDATION OF GROUND-BASED EMPIRICAL MODELS AND COMPUTER CODES
ACCOMPLISHMENTS	● FLOWN SUCCESSFULLY ABOARD STS-43, AUG 2, 1991 ● VERIFIED THAT JET-INDUCED FLUID MIXING TECHNOLOGY IS AN EFFECTIVE PRESSURE CONTROL TECHNIQUE FOR LOW-GRAVITY CRYOGENIC TANKS ● OBTAINED EXCELLENT VIDEO DATA FOR COMPARISON OF FLUID DYNAMICS WITH DROP TOWER RESULTS AND PRELIMINARY COMPUTATIONAL RESULTS ● OBTAINED EXTENDED LOW-G TEMPERATURE/PRESSURE DATA FOR DETERMINATION OF FLUID MIXING TIMES
BENEFITS	● ENABLES THE USE OF LIGHTER WEIGHT CRYOGENIC TANKS FOR SPACE PLATFORMS & ADVANCED TRANSPORTATION SYSTEMS ● VIDEO AND DATA RESULTS ENABLE ACCURATE UPGRADING AND VALIDATION OF GROUND-BASED EMPIRICAL MODELS AND COMPUTER CODES
APPLICABLE MISSIONS	● FUTURE SPACE TRANSPORTATION SYSTEMS, DEPOTS, SATELLITES, AND INSTALLATIONS THAT UTILIZE CRYOGENIC FLUIDS

IN-STEP FY91

R&T BASE



REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	April 1992	Final - FY1991 Technical Memorandum

4. TITLE AND SUBTITLE
OAST Space Technology Accomplishments FY 1991

5. FUNDING NUMBERS

6. AUTHOR(S)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Office for Aeronautics and Space Technology

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, D. C. 20546

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM-4369

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Unlimited - Unclassified
Subject Category 99

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

The program consists of a continuum of space research and technology activities ranging from initial research to the full-scale test of prototype equipment in space. Activities include work that is performed by in-house staff at the NASA Centers, University researchers supported by NASA-funded grants and contracts, and industrial aerospace organizations under contract to NASA. These diverse activities provide advances in technology breakthroughs that may revolutionalize a technical discipline or mission concept. The work is managed and coordinated by OAST through a process that integrates the best available talent and capability in NASA, industry, and universities into a National civil space research and technology program.

14. SUBJECT TERMS
space science
sensing
space energy
space transportation
aerothermodynamics

15. NUMBER OF PAGES
184

16. PRICE CODE
A09

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	Unlimited

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102